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PRODUCTIVITY GROWTH PATTERNS IN U.S. FOOD MANUFACTURING: CASE OF DAIRY PRODUCTS INDUSTRY

by

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Abstract

A panel constructed from the Census Bureau's Longitudinal Research Database is used to measure total factor productivity growth at the plant-level and analyzes the multifactor bias of technical change at three-digit product group level containing five different four-digit sub-group categories for the U.S. dairy products industry from 1972 through 1995. In the TFP growth decomposition, analyzing the growth and its components according to the quartile ranks show that scale effect is the most significant element of TFP growth except the plants in the third quartile rank where technical change dominates throughout the time periods. The exogenous input bias results show that throughout the time periods, technical change is 1) capital-using; 2) labor-using after 1980; 3) material-saving except 1981-1985 period; and, 4) energy-using except 1981-1985 and 1991-1995 periods. Plant productivity analysis indicate that less than 50% of the plants in the dairy products industry stay in the same category, indicating considerable movement between productivity rank categories. Investment analysis results indicate that plant-level investments are quite lumpy since a relatively small percent of observations account for a disproportionate share of overall investment. Productivity growth is found to be positively correlated with recent investment spikes for plants with TFP ranking in the middle two quartiles and uncorrelated with plants in the smallest and largest quartiles. Similarly, past TFP growth rates present no significant correlation with future investment spikes for plants in any quartile.

Key Words: Total Factor Productivity Growth, Input Bias of Technical Change, Lumpy Investment, U.S. Dairy Products Manufacturing

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I. Introduction

A major branch of the productivity growth literature based on the aggregate total factor productivity (TFP) growth applies the representative agent framework to sectoral or industrial data. In these studies, productivity growth arises from the shift of the production function common to all plants in the industry or sector through efficient allocation of the factors of production, or through improvements in the quality of the factors of production (Bartelsman and Dhrymes, 1998). However, recent studies find that use of the representative agent framework with sectoral data leads to problems in measuring aggregate total factor productivity. For example, Dhrymes (1991) and Bartelsman and Dhrymes (1998) find that two-digit industry wide productivity, and its growth over time, may be reduced considerably when the four-digit industry composition of the sample is addressed. Hence, a disaggregated analysis can provide a more detailed and revealing perspective of the dynamics of TFP growth when compared with the aggregate level analysis of TFP growth.

The overall goal of this paper is to address the measurement and implications of productivity growth when an individual plant is considered as a decision-making unit. The paper analyzes the productivity patterns in the dairy products industry by focusing on large manufacturing plants with the available establishment level data from 1972 through 1995. The model presents a theoretically consistent methodology in measuring total factor productivity growth at the plant-level and analyzes the multifactor bias of technical change in the dairy products industry. A Translog production function estimating the fixed effects regression in the industry is used to calculate TFP growth. The industry average TFP, scale effect, technical change effect and returns to scale are evaluated to

gauge the industry's performance through time. The TFP growth of plants is ranked and the corresponding components (technical change and scale effects) and returns to scale are separated into quartile groups. The multifactor bias of technical change is investigated using the marginal products as weights. The method to analyze the plant level TFP growth enables the classification of the plants exhibiting varying levels of TFP as well as the investigation of whether the productivity is growing over time.

Analyzing the productivity and technical changes for the dairy products sub-industry in the U.S. Food and Kindred Product Industry presents an interesting case study for the investigation of plant-level productivity dynamics associated with the food industry characteristics. Similar analyses considering the meat products sub-industry finds wide differences in productivity levels and industry characteristics (see Celikkol and Stefanou, 2004). Therefore, an analysis focusing on the sub-industry level even when each sub-group belongs to same two digit level aggregate industry shows very different results in productivity growth measurements.

The U.S. dairy products sub-industry (along with the canned, frozen, preserved fruits, vegetables sub-industry) has the second largest percentage of plants (13%) which have survived through 1972-1995 based on the total number of plants among all food manufacturing. Considering the balanced panel of all food plants, the dairy products sub-industry is the fourth largest sub-industry among others based on the material expenditure with 11.2% of total industry's material expenditures. Dairy products sub-industry account for 7.3% of total food and kindred products industry's energy expenditure, 6.1% of employment expenditures, 6.3% of combined machinery and building investment expenditures as well as 6.1% of machinery investment expenditures and 7.2% of building

investment expenditures. The dairy products sub-industry's total value of shipments is the fifth largest with 9.3% of total food and kindred products industry's total value of shipments.

Over the last two decades across the food processing industry, the number of establishments has declined with the dairy products sub-industry losing the most establishments (approximately 190 establishments).¹ Mergers and acquisitions are also seen in the dairy products sub-industry and concentration continues to increase. For example, Harris (2002) reports that large dairy processing firms account for an increase share of dairy sales and companies with \$800 million or more in sales account for 69% of U.S. dairy sales in 1998. Large U.S. dairy cooperatives gained market share from 17% in 1975 to 27% in 1998 relative to proprietary dairy companies, which experienced market share growth from 39% to 42% over the same period.

Generally, plant-level studies analyzing the productivity dynamics in the literature concentrate on the overall manufacturing plants in U.S. focusing mostly on the pooled sample data analysis that primarily concentrates on the aggregate level. This paper contributes to the literature taking the dairy products sector as case study analyzing the productivity dynamics at the most disaggregated level.

II. Nature and Significance of the Problem

¹ Harris (2002) reports that the number of food processing plants rose 5% from 1992 to 1997. However, it is noted that this increase is observed in some selected industries where the small number of food processors has increased such as small salsa makers.

Accurate measurement of productivity growth plays a critical role in contributing to the future decision-making in industry and government policy-making strategies. In a productivity growth analysis of a sector or an industry considering the individual plant as a decision unit contributes to our understanding of productivity growth. The most common method used in the literature is the representative agent framework, which has been widely applied in various sectors and industries. Nevertheless, this approach has some limiting assumptions such as frictionless adjustment in factor shocks, competitive product and factor markets, and identical constant returns technologies at all plants. Studies find that violations of any of these assumptions can lead to procyclical bias in measured productivity growth and systematic under- or over-statements (see Nelson, 1981; Berndt and Fuss, 1986; Hall, 1988; Morrison, 1989). Improvements in the exploitation of scale economies makes it difficult to distinguish the contributions of productivity improvements common to all plants from the contributions of heterogeneity effects which are attributed to entry, exit, diffusion, and plant-specific scale effects of learning (Roberts and Tybout, 1996). Therefore, these issues can be addressed by examining the plant-level data, which also provides a better understanding for the aggregation problems in total productivity growth measurement. Analyzing productivity growth at the plant level provides the flexibility to compare the behavior of each plant throughout the time period as well as our understanding of the aggregate level of productivity growth of the firms in the industry.

Empirical analysis of the productivity transition of plants employs the Longitudinal Research Database in the U.S. Census Bureau containing the establishment-level production data from the Annual Survey of Manufacturers and Census of

Manufacturers. This non-publicly available Census data is used in this study for understanding the productivity patterns, analyzing the aggregation issue in the productivity measurement and the performance of the industry micro-and macro-level.

Existing Economic Models

Better understanding of sector-wide performance can be realized by focusing on the disaggregated plant-level dynamics of productivity. Studies focusing on the theoretical frameworks of industry dynamics [i.e., Jovanovic (1982), Hopenhayn (1992), Ericson and Pakes (1995)] try to explain how plants or firms in the industry with differing productivities can exist, and why entry and exit can occur simultaneously. Many micro-level empirical studies analyze the range of issues related to productivity dynamics following the theoretical framework of industry dynamics developed by Jovanovic, Hopenhayn, Ericson and Pakes [see Baily, Hulten and Campbell (1992), Pakes and Ericson (1989), Olley and Pakes (1992), Hall and Mairesse (1995), Bahk and Gort (1993), Dunne et al. (1989) and Baldwin and Gorecki (1991)].

Baily, Hulten and Campbell (1992) focus on the cross-sectional distribution in productivity at the plant level in the manufacturing sector and discuss how changes in this distribution along with changes in market shares influences aggregate productivity. Their study shows that entry and exit play only a very small role in industry growth over five-year periods and that increasing shares of output in high-productivity plants and decreasing shares of output in low-productivity plants are important to the growth of manufacturing productivity.

Bartelsman and Dhrymes (1998) analyze empirically the behavior of cross-sectional distribution of productivity using several different methodologies to measure TFP derived from production functions, Solow-residual and Corrected-Solow residual-derived measure of TFP, and then compare their behavior over time using non-parametric tools. They compare the average TFP, which has grown substantially over the time period, with average plant level TFP, which has declined or remained flat. In contrast to Baily, Hulten and Campbell (1992), they show how all their results vary by the method used to measure TFP. They use transition matrices to examine the persistence of plant productivity and they show that transition probabilities vary by industry, plant age, and other characteristics. Although there are various studies documenting the plant-level productivity transitions over time and investigating the heterogeneous plant level characteristics in the productivity analysis [such as Bartelsman and Dhrymes (1998), Baily, Hulten and Campbell (1992)], this paper differs from these studies by focusing on the disaggregated industry sample design and emphasizes the detailed TFP growth analysis via decomposing TFP growth by scale and technical change effects.

III. Methodology

There are three static methodologies measuring productivity in the literature which can be categorized into three approaches: i) index-number approach, ii) explicit specification of a production function and direct linkage of productivity growth to the parameters of this production function, and iii) the measurement of productivity based on the cost function model. In this paper, explicit specification of a production function and

direct linkage of productivity growth to the parameters of this production function is used.

Total factor productivity measurement has been widely used in the literature starting from the early work of Solow (1957) known as “Solow residual.” Later, TFP is calculated using the econometric approach. The econometric approach estimates the underlying parameters based on production function. This involves the explicit specification of a production function and the direct linkage of productivity growth to the parameters of this production function. In general, production function is defined as

$$Q_{it} = F_i(X_{i1}, \dots, X_{in}, t). \quad (1)$$

where t denotes the time period, Q_{it} denotes output of plant i in period t , and X_{ij} denotes the level of inputs j of plant i , $j=1, \dots, n$. Following the well-known approach of decomposing TFP growth, totally differentiating (1) and dropping the subscripts i and t yields:

$$dQ = \sum_{j=1}^n F_{X_j} dX_j + F_t dt \quad (2)$$

Dividing (2) through Q and dt and rearranging the terms yields;

$$\frac{dQ_t}{dt} \frac{1}{Q_t} = \frac{d \ln Q_t}{dt} = \sum_{j=1}^n \frac{F_{X_j} X_j}{Q} \frac{d \ln X_j}{dt} + \frac{F_t}{Q}. \quad (3)$$

which can also be written as

$$\hat{Q} = \sum_{j=1}^n \frac{F_{X_j} X_j}{Q} \hat{X}_j + \hat{A} \quad (4)$$

where “ $\hat{\cdot}$ ” indicates proportional growth rates (i.e., $\hat{Q} = \frac{\dot{Q}}{Q}$) and $\hat{A} = \frac{\dot{F}_t}{F_t}$ represents the

proportional shift in the firm specific production function due to the exogenous technical

change. Then multiplying and dividing equation (4) through $\sum_{j=1}^n F_{X_j} X_j$ leads to

$$\hat{Q} = \sum_{j=1}^n \frac{F_{X_j} X_j}{Q} \left[\sum_{j=1}^n \frac{F_{X_j} X_j}{\sum_{j=1}^n F_{X_j} X_j} \hat{X}_j \right] + \hat{A} \quad (5)$$

The elasticity of scale is defined as $\varepsilon = \sum_{j=1}^n \varepsilon_j$ where $\varepsilon_j = \frac{F_{X_j} X_j}{Q}$ therefore

$\varepsilon = \sum_{j=1}^n \frac{F_{X_j} X_j}{Q}$, the sum of all production elasticities and measures returns to scale of the

technology. An aggregate input is created using the Divisia form $\hat{F} = \sum_{j=1}^n \frac{w_j X_j}{C} \frac{d \ln X_j}{dt}$.

In the absence of prices, we can use the first order conditions of cost minimization where

$w_j = \frac{\partial C}{\partial Q} F_{X_j}$, which also implies that total costs, C , can be expressed in terms of the

production function parameters

$$C = \sum_{j=1}^n w_j X_j = \sum_{j=1}^n \frac{\partial C}{\partial Q} F_{X_j} X_j = \frac{\partial C}{\partial Q} \sum_{j=1}^n F_{X_j} X_j. \quad (6)$$

The aggregate input term is defined

$$\hat{F} = \sum_{j=1}^n \frac{w_j X_j}{C} \frac{d \ln X_j}{dt} = \sum_{j=1}^n \frac{F_{X_j} X_j}{\sum_{j=1}^n F_{X_j} X_j} \hat{X}_j \quad (7)$$

where the marginal cost term, $\frac{\partial C}{\partial Q}$, cancels out. Using equation (7) in (5) leads to proportional actual output growth being written as

$$\hat{Q} = \sum_{j=1}^n \frac{F_{X_j} X_j}{Q} \hat{F} + \hat{A} \quad (8)$$

where $\sum_{j=1}^n \frac{F_{X_j} X_j}{Q} \hat{F}$ is the scale effect (input growth), \hat{A} is the exogenous technological change effect.

Total factor productivity growth (\hat{TFP}) is defined as the residual growth in output, not accounted for by the growth in inputs,

$$\hat{TFP} = \hat{Q} - \hat{F}. \quad (9)$$

Inserting equation (5) in equation (9) represents the total factor productivity growth expressed in terms of the production function specification as

$$\hat{TFP} = (\varepsilon - 1) \hat{F} + \hat{A} = \left(\sum_{j=1}^n \frac{F_{X_j} X_j}{Q} - 1 \right) \sum_{j=1}^n \frac{F_{X_j} X_j}{\sum_{i=1}^n F_{X_j} X_j} \hat{X}_j + \hat{A}. \quad (10)$$

Measuring Input Bias of Technical Change

The multifactor input bias measure are introduced by Binswanger (1974) using the changes in factor cost shares attributed to technical change. Antle (1984) develops a profit-based multifactor measure of biased technical change, which is equivalent to the

cost-share approach. Following the Antle (1984) multifactor measure of input bias,

define the j th production elasticity share as $\varepsilon_j / \varepsilon$ where $\varepsilon_j = \frac{F_{X_j} X_j}{F}$, F_{X_j} is the

marginal product of X_j and $\varepsilon = \sum_j^n \varepsilon_j$. The impact of technical progress on input

decisions for factor j can be attributed to exogenous technical change, measured by

$$B_{jt} = \frac{\partial \ln(\varepsilon_j / \varepsilon)}{\partial \ln T}. \quad (11)$$

The equation (11) indicates that exogenous technical change is biased towards the j^{th} factor (capital, labor, material, energy) if B_{jt} is positive (factor using), is biased against the j^{th} factor if B_{jt} is negative (factor saving), and is neutral if B_{jt} is equal to zero.

IV. Empirical Model Specification and Estimation

The empirical estimation specifies a translog production function². The dependent variable $\ln Q_{it}$ is the output of plant i at time t and there are four inputs: capital, labor, materials and energy. Production function is specified as

$$\ln Q_{it} = \alpha_o + \sum_{j=1}^n \alpha_j \ln X_{itj} + \frac{1}{2} \sum_{j=1}^n \sum_{s=1}^m \alpha_{js} \ln X_{itj} \ln X_{its} + \beta_0 T + \frac{1}{2} \beta_1 T^2 + \sum_{j=1}^n \beta_j \ln X_{itj} T \quad (12)$$

² The translog production function is the best fitting functional form for this sub-industry where the best functional form for the production function estimation chosen for the industry based on the following criteria: positive marginal products, second order conditions satisfying the appropriate curvature conditions, an average returns to scale with a reasonable range (e.g., 0.5-1.5) and goodness-of-fit measurement. The translog production function is selected to be suitable for the dairy products sub-industry with a 0.92 reasonable average returns to scale range and with a 0.83 R^2 measurement. Further, the percentage of observations with positive marginal products is 94% for K, 100% for both L and M, and 89% for E. The Hessian is negative semi-definite for a considerable percentage of the plant observations.

where $j, s = K, L, M, E$ $\alpha_{js} = \alpha_{sj}$, $j \neq s$.

The problem of production function estimation with OLS is the potential endogeneity of input decisions as well as output. If there is unobserved heterogeneity across plants, the estimated coefficients from the regressions, which do not control fixed effects, will be biased. If time-invariant plant characteristics exist then failing to control for these characteristics when using pooled cross-section time series data will cause the error term, the dependent variable, and possibly several explanatory variables to be correlated over time. Therefore, plant-level fixed effects remove time-invariant differences in mean productivity across plants. The regression with plant-level fixed effects eliminates this potential source of bias.

While the balanced nature of the data set ensures the construction of capital stocks for plants using the perpetual inventory method to investigate investment spikes and lumpiness, it does not permit extensive modeling of the entry/exit process. The immediate consequence is that the estimated capital elasticity will be biased downward in accordance with the Olley and Pakes (1996) critique of the selectivity bias problem for balance data set which ignores the plant entry and exit processes.

The estimated coefficients using the fixed-effect regression with 4-digit industry dummies (4-digit composition of output) of the translog production function are used to generate the scale and technical change effects. Table A.1 in the Appendix presents the coefficient estimates, t -statistics, Breusch and Pagan Lagrange Multiplier test, Hausman

test and their p-values based on the best-fitting production technology for dairy products sub-industry.³

Figure 1 presents the annual average TFP growth indicating that the dairy products sub-industry follows a stable pattern around zero after 1979. Prior to 1979, plant level productivity increases significantly. Most of the studies show that the path of mean plant level productivity follows different productivity patterns once we consider the individual sub-industries (such as the dairy products sub-industry in this case) separately versus pooling all the industries into an entire single manufacturing industry.

We compare the TFP, which is predicted by scale and technical change components using the production function estimation results, $(\varepsilon - 1)\hat{F} + \hat{A}$, with the TFP calculated using output growth (from the data) less aggregate input growth, $\hat{Y} - \hat{F}$, to find whether the residuals are over- or under-estimated. Figure 2 presents the mean residual graph for the dairy products sub-industry. The residuals are around zero after 1976 but TFP is underestimated in years 1973, 1974, 1975 and 1990⁴.

Table 2 presents an overview of productivity changes of the plants during the period 1973-1995, summarizing the average TFP growth by periods in the dairy products

³ Lagrange multiplier test for the random effect is applied to compare the OLS versus random effect model estimations. The null hypothesis is rejected for the industry suggesting that the classical regression model with single constant term is inappropriate and that the random effect model is preferred. Hausman specification test which assesses the equality of the coefficients estimated by the fixed- and random-effects estimators examines the appropriateness of the random-effect estimator under the assumption of a correctly specified model. Hausman test's null hypothesis is that the difference in coefficients (fixed and random effect model's coefficients) is not systematic (or individual effects are uncorrelated). The result is to reject null hypothesis. Based on these two tests, this study uses fixed effect regression in the production function estimation.

⁴ The residuals are usually around zero means that they are in the range of ± 5 percent deviation. If the residuals are out of this range according to the sign, we signify TFP is under-estimated or over-estimated.

sub-industry. The average plant-level TFP growth in this sub-industry indicates that TFP growth is only positive with a 0.15% growth rate during the 1976-1980 period, averaging -0.3% growth throughout the time periods⁵.

Table 2. Average TFP Growth without Ranking Plants in Dairy Products Sub-Industry

Time Period	Mean TFP	Mean Scale	Mean Technical Change	Mean Returns to Scale
1973-1975	-0.00129	-0.00716	0.005854	0.90955
1976-1980	0.001454	-0.00397	0.005426	0.91817
1981-1985	-0.00079	-0.00248	0.001688	0.92562
1986-1990	-0.00459	-0.00125	-0.00335	0.9308
1991-1995	-0.00999	-0.00127	-0.00872	0.93482
1973-1995	-0.0032	-0.00289	-0.00031	0.92503

Additional Table Notes: In Appendix, Table A.2 shows the detailed un-weighted mean TFP decomposition in each year.

TFP Decomposition According to Quartile Ranks

Similar to Dhrymes's (1991) ranking procedure, this study applies the contemporaneous rank procedure to TFP growth and its components to address plant-level TFP growth in the dairy products sub-industry. After calculating TFP growth corresponding to a given plant, plants are ranked according to the magnitudes of their TFP in each year. Then plants are grouped according to these ranks by a quartile sampling procedure with 0 reflecting the lowest quartile group and 3 denoting the highest quartile. The analysis of the average TFP growth and its components (scale and technical

⁵ Table A.2 in the Appendix indicates that the dairy products sub-industry follows an increasing pattern prior to 1979, become stable during 1979-1989 and follows a declining pattern after 1986. This can also be seen from the Figure 1 that there are three different stages for the dairy plants and there exists considerable fluctuation in the TFP growth behavior of this sub-industry throughout the time periods.

change effects) in each rank for the dairy products sub-industry are presented for the following time periods: 1973-1975; 1976-1980; 1981-1985; 1986-1990; 1991-1995.

Table 3 presents average TFP growth and its components (scale and technical change effects) for each rank with an average returns to scale during the five prescribed time periods and indicates, on average, that the dairy products sub-industry follows decreasing returns to scale in each rank, ranging from the 0.92-0.93. Average returns to scale is calculated by finding the point estimates of the returns to scale for each plants and grouping them according to their TFP quartiles and then taking the average of each time period for each rank.

Table 3. Total Factor Productivity Growth Rankings and TFP Growth Components through 1973-1995

TFP RANK 0				
Time Period	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973-1975	-0.02758	-0.032	0.00442	0.90423
1976-1980	-0.01458	-0.01897	0.004385	0.91563
1981-1985	-0.01584	-0.01644	0.0006	0.92261
1986-1990	-0.01919	-0.01498	-0.00421	0.92763
1991-1995	-0.02266	-0.01315	-0.00952	0.93299
1973-1995	-0.01931	-0.01799	-0.00132	0.922043
TFP RANK 1				
Time Period	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973-1975	-0.00201	-0.00738	0.00537	0.90825
1976-1980	-0.00029	-0.00469	0.004405	0.91834
1981-1985	-0.00283	-0.00406	0.001225	0.92662
1986-1990	-0.00679	-0.00313	-0.00366	0.93086
1991-1995	-0.01181	-0.0027	-0.00911	0.93722
1973-1995	-0.00498	-0.00413	-0.00085	0.925652
TFP RANK 2				
Time Period	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973-1975	0.005388	-0.00129	0.006674	0.91124
1976-1980	0.005494	-0.00064	0.006136	0.91909
1981-1985	0.002179	-0.00025	0.002425	0.92812

1986-1990	-0.00259	0.000141	-0.00273	0.93294
1991-1995	-0.00793	0.000385	-0.00831	0.93577
1973-1995	0.00008	-0.00025	0.000331	0.926667
TFP RANK 3				
Time Period	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973-1975	0.018844	0.01183	0.007014	0.91433
1976-1980	0.014999	0.008231	0.006768	0.91964
1981-1985	0.013139	0.010653	0.002486	0.92503
1986-1990	0.01018	0.012971	-0.00279	0.93173
1991-1995	0.002416	0.010342	-0.00793	0.93326
1973-1995	0.011313	0.010717	0.000597	0.92571

Additional Table Notes: This decomposition according to quartile ranks for each year can be seen in Appendix, Tables A. 3a-A.3d.

Figure 3 presents the average productivity growth for each quartile group, the lowest graph corresponds to the first quartile (rank 0), and the next corresponds the second quartile (rank 1) and so on. In the dairy products sub-industry, the time profile of productivity growth for all quartile groups indicates that plants in TFP ranks 1 and 2 generally follow a similar pattern with a small constant gap between each other throughout the time period. Plants that are in the lowest and the highest growth categories have considerable gaps compared to the other groups. The lowest ranked plants try to close the gap between the other categories until 1977 and after 1977 the gap between other groups of plants stay constant until the end of the period. The plants in TFP rank 0 present the most fluctuating productivity growth rates during the period under study.

Overall, there is a considerable gap between the TFP growth ranks, in particular between the highest and the lowest TFP ranked plants. The TFP growth results in all years, on average, show that the gaps between these TFP ranks are considerable. For example, while the lowest ranked plants' productivity growth averages -1.9% , the highest ranked plants' productivity growth averages 1.1% .

TFP growth components from Table 3 show that the scale effect has the most significant contribution to the TFP growth measurement for the plants in the lowest rank group (rank 0) and the highest rank group (rank 3) throughout the time period. The scale effect is also dominating for the first three time periods of the plants in rank TFP 1 group. The scale effect contributions to TFP measurement are in the negative direction for the plants in ranks 0 and 1 and positive for the plants in rank 3. For the plants in TFP rank 1, there is a significant technical change effect on TFP growth in the negative direction between 1986-1995, even though the scale effect is the powerful component. For the plants in TFP rank 2, the technical change effect presents the most significant contribution to the TFP growth measurement and this contribution is positive up to 1985 and the negative thereafter (see figures 4-7). Plants in the lowest, middle and the highest ranks extract scale efficiencies over technological progress to fuel TFP growth. For the lowest TFP ranked plants, this suggests that these plants cannot afford to realize higher productivity growth through technological adoption but they have the potential to reorganize input allocations to achieve productivity growth.

V. Input Bias of Technical Change in Dairy Products Sub-industry

Table 4 summarizes exogenous input bias results (see figure 8) and shows that technical change is biased toward the capital input in a declining magnitude from 21% (from 1976-1980) to 5.2%, averaging 10.4% overall years. For the labor input, technical change is biased toward the labor input after the 1976-1980 period in a fluctuating magnitude, averaging 9.5%. For the material input, technical change is biased against the materials input (except for 1981-1985) with a stable magnitude, averaging -0.18% over

all years. The direction of technical change fluctuates against the energy input during the 1981-1985 and 1991-1995 periods and towards the energy input in rest of the periods, averaging -2.6% throughout the years.

Table 4. Multifactor Bias in Technical Change for Sub-Period Averages in Dairy Products Sub-Industry

Time Period	Mean Capital Input	Mean Labor Input	Mean Materials Input	Mean Energy Input
1973-1975	0.06057	-0.02009	-0.00791	0.12014
1976-1980	0.21315	-0.00208	-0.0023	0.06838
1981-1985	0.10833	0.13954	0.001561	-0.0787
1986-1990	0.06864	0.25623	-0.00174	0.01915
1991-1995	0.05163	0.05516	-0.00111	-0.20114
1973-1995	0.10393	0.09496	-0.00181	-0.02614

Additional Table Notes: This result is also presented for each year in the Appendix, Table A.4.

VI. Plant's Size Effects to Productivity

Plants sizes are arranged into four categories with size A reflecting the smallest to size D for the largest plants. The direct size effects on TFP growth analysis presented in table 5 indicate that plants in the middle (size category B) and middle-larger (size category C) size categories have the highest average growth rate, on average. In each period, different size categories become effective with respect to their productivity levels therefore, in overall, two middle size categories have the highest TFP growth.

Table 5. Direct Effect of Size Categories to Average TFP Growth

Time Period	Size A (The Smallest)	Size B (Middle)	Size C (Middle-Larger)	Size D (The Largest)
1973-1975	0.000413	0.000255	-0.00058	-0.00514
1976-1980	-0.00045	0.001985	0.003255	0.00102
1981-1985	-0.00167	-0.00064	-0.00071	-0.00016
1986-1990	-0.00572	-0.00377	-0.00488	-0.00405
1991-1995	-0.01155	-0.00946	-0.00943	-0.00953
1973-1995	-0.00416	-0.00255	-0.00263	-0.00344

Additional Table Note: TFP decomposition by plant size categories over time periods is presented in Appendix, Tables A.5a-A.5d.

Investigation of the technical change contribution on TFP growth across plant sizes presented in tables A.5 in the Appendix indicates that on average the smallest sized plants (size category A) have the highest technological change contribution on TFP growth in a same (negative) direction with TFP throughout the time periods. But, sub-period averages indicate that plants in the middle size category dominate based on their technical change contribution to TFP during the 1973-75, 1986-1990 and 1991-1995 periods.

Secondary Decomposition of TFP Growth based on Size Categories

This section investigates the detailed decomposition of TFP growth with respect to size groups. The different size groups are summarized in Table 6 for each TFP rank.

Table 6. Plant's Size Categories Effect on Average TFP Growth according to Productivity Rank Groups

TFP RANK 0				
Time Period	Size A (The Smallest)	Size B (Middle)	Size C (Middle-Larger)	Size D (The Largest)
1973-1975	-0.02316	-0.02141	-0.02562	-0.04119
1976-1980	-0.01525	-0.01528	-0.01157	-0.01649
1981-1985	-0.01320	-0.01405	-0.01393	-0.02250
1986-1990	-0.01543	-0.01868	-0.01889	-0.02345
1991-1995	-0.02335	-0.02338	-0.02330	-0.02066
1973-1995	-0.01763	-0.01831	-0.01805	-0.02344
TFP RANK 1				
Time Period	Size A (The Smallest)	Size B (Middle)	Size C (Middle-Larger)	Size D (The Largest)
1973-1975	-0.00217	-0.00200	-0.00208	-0.00181
1976-1980	-0.00018	-0.00013	-0.00050	-0.00033
1981-1985	-0.00328	-0.00273	-0.00262	-0.00275
1986-1990	-0.00709	-0.00669	-0.00645	-0.00697
1991-1995	-0.01173	-0.01189	-0.01167	-0.01195
1973-1995	-0.00512	-0.00492	-0.00489	-0.00502
TFP RANK 2				
Time Period	Size A (The Smallest)	Size B (Middle)	Size C (Middle-Larger)	Size D (The Largest)
1973-1975	0.005711	0.005197	0.005618	0.005085
1976-1980	0.005135	0.005519	0.005728	0.005574
1981-1985	0.002172	0.002202	0.002014	0.002326
1986-1990	-0.00269	-0.00254	-0.0026	-0.00252
1991-1995	-0.00797	-0.00795	-0.00805	-0.00775
1973-1995	1.56957E-05	7.6913E-05	9.95652E-05	0.000148
TFP RANK 3				
Time Period	Size A (The Smallest)	Size B (Middle)	Size C (Middle-Larger)	Size D (The Largest)
1973-1975	0.016295	0.018443	0.018450	0.021901
1976-1980	0.015776	0.013974	0.015194	0.015131
1981-1985	0.012236	0.010627	0.014442	0.015354
1986-1990	0.005502	0.006791	0.011565	0.017093
1991-1995	0.003766	0.001126	0.003276	0.001602
1973-1995	0.010230	0.009475	0.012075	0.013548

Additional Table Notes: TFP and Size decomposition categories over time periods is presented in Appendix, Tables A.6a-A.6d.

The table shows that the smallest-sized plants (size category A) present the highest average TFP growth for the lowest TFP rank (rank 0). In this rank category, on average, plants in size categories A, B and C have a similar productivity growth rate (approximately, -1.8%). However, in TFP ranks 1 and 2, plants in all different size categories have very close productivity growth rates on average with a -0.5% and 0.01% rate, respectively, suggesting there is no significant size effect. For the TFP Rank 3 category, plants in size category D with 1.4% productivity growth rate on average play a dominant role compared to productivity growth rates in other size categories, indicating the size effect is evident for the plants in TFP rank 3. In general, the size effect is evident in all TFP ranks except in ranks 1 and 2 which present a robust productivity across all size categories and with a significant productivity in size D category in TFP rank 3 compared to the other size categories.

VI. Plant Productivity Transitions

This section analyzes plants' productivity transitions between periods to assess whether plants occupy a fixed rank with respect to their productivity levels or vary in their productivity rankings. These matrices are constructed to address plant switching behavior based on quartile ranks. The transition matrices are organized by assigning a plant to a quartile group in the cross sectional distribution of TFP in each year based on the value of its TFP measure and then tabulating the incidence of transition of plants from quartile $q(t)$ in a year t to quartile $q(t+5)$ in year $t+5$; i.e., this is a 4×4 matrix with each element presenting the proportion of plants making the transition from quartile i to quartile j over a five period ($i, j = 0, 1, 2, 3$ quartiles).

Table 7 presents number of times in plants' productivity transitions and their corresponding percentages in five-year periods from 1976 to 1991. Using the dummy variable approach to capture the differences in the age of plants, we can only assign an approximate age for the plants in our sample when comparing the plants which exist in earlier years (1963 or 1967) to the plants already in existence in 1972. For example, since LRD does not contain ASM panels prior to 1969, if a plant were not included in 1963 Census but were included in 1967, the plant could be anywhere from five to nine years old in 1972. Therefore, the exact age cannot be constructed for the plants already in existence in 1972. Similar to the Doms and Dunne (1994) approach, this study assigns the dummy variables as follows: DA1: if plant exists in 1963, 9 years old plant when we compare with year 1972; DA2: if plants exists in 1967, ranging potentially between 5 to 9 years old age); and, the remaining plants are born in 1972 (considered the youngest plants in our sample period).

Table 7. Plant Productivity Quartile Category Switching Percentages

	No Switching	Switching Once	Switching Twice	Switching Three Times
All Industry	0	0.19	0.41	0.39
Age 1	0	0.08	0.46	0.46
Age 2	0	0.13	0.53	0.33
Age 3	0	0.22	0.47	0.38

In the dairy products sub-industry, all of the plants change their productivity growth ranking at least once. In all the age categories and the industry plants together, the percentage of plants which are switching twice is high such that 41% of all plants pooled together, 46% of the youngest plants, 53% of plants in age category 2 and 47% of the

oldest plants switch twice throughout the time periods, indicating considerable movement in plants' productivity categories for this sub-industry.

The following table presents the summary of plants' productivity transitions through the time periods in the dairy products sub-industry and the transition of plants' productivity across age categories. Similar to Barteslman and Dhrymes (1998), these transition tables present **Gain** to indicate productivity improvements by one or more quartile ranks, **Lose** to indicate plants' productivity transition downward by one or more quartile ranks, and **Stay** to indicate plants remaining at the fixed rank throughout the selected time period.

Table 8. Dairy Products Sub-Industry Plants' Productivity Transition Behaviors in overall and across Age Categories

1976 vs. 1981										
	Gain			Lose			Stay			
	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank
	0	1	2	1	2	3	0	1	2	3
All Industry	0.71	0.37	0.33	0.32	0.28	0.82	0.29	0.32	0.38	0.18
Age 1	0.89	0.14	0.60	0.57	0.40	1.00	0.11	0.29	0	0
Age 2	0.75	0.50	0.25	0.25	0	1.00	0.25	0.25	0.75	0
Age 3	0.64	0.41	0.30	0.26	0.30	0.77	0.36	0.33	0.40	0.23
1981 vs. 1986										
	Gain			Lose			Stay			
	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank
	0	1	2	1	2	3	0	1	2	3
All Industry	0.74	0.54	0.18	0.21	0.51	0.86	0.26	0.23	0.31	0.14
Age 1	0.83	0.40	0.20	0.20	0.40	0.80	0.17	0.40	0.40	0.20
Age 2	0	0.33	0.43	0.67	0.29	0.67	1.00	0	0.29	0.33
Age 3	0.77	0.62	0.11	0.15	0.59	0.89	0.23	0.19	0.30	0.11
1986 vs. 1991										
	Gain			Lose			Stay			
	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank
	0	1	2	1	2	3	0	1	2	3

All	0.74	0.58	0.16	0.18	0.58	0.71	0.26	0.24	0.26	0.29
Industry										
Age 1	0.80	0.75	0	0	1.00	0.80	0.20	0.25	0	0.20
Age 2	1.00	0	0	1.00	0.50	1.00	0	0	0.50	0
Age 3	0.68	0.55	0.19	0.21	0.55	0.61	0.32	0.24	0.26	0.39

Additional Table Notes: These transition tables are presented in detail for each year considering plants' ranks across all industry and age categories in the Appendix, Tables A.7, A.8, A.9, A.10.

Table 8 presents that 71% of plants move up from rank 0, improving their productivity from 1976 to 1981. During the same period, 37% of the plants in rank 1 improve their productivities and 32% of them drop in their productivity rank, 33% of rank 2 plants improve and 28% of them drop in their productivity rank, and 82 % of rank 3 plants drop in their productivity rank.

During the time period 1981-1986, 74% of the plants in rank 0 improve their productivity, and 54% of plants in rank 1 improve and 21% of the plants in rank 1 drop in their productivity rank. For the plants in rank 2, 18% of them improve and 51% of them drop in their productivity rank and 86% of plants in the rank 3 drop in their productivity rank. Similarly, during the time period 1986-1991, 74% of the plants in rank 0 improve their productivity, 58% of plants in rank 1 improve and 18% of rank 1 plants drop in, 16% of plants in rank 2 improve and 58% of them drop in their productivity ranks and 71% of plants in rank 3 plants drop in their productivity ranks. Other than 75% of plants in age 2 and rank 2 from 1976 to 1981 and all of the plants in age 2 and rank 0 from 1981 to 1986, in no case do more than 50% of the plants stay in the same category, indicating considerable movement between productivity rank categories for the plants in the dairy products sub-industry.

The analysis of the plants in age category 1 shows that less than 50% of the plants in all ranks and time periods stay in the same category. In particular, no plants in rank 2

and 3 during the 1976 to 1981 and rank 2 during the 1986 to 1991 stay in the same category, indicating considerable movement in the youngest plants' productivity ranks. Plants in rank 3 present a significant productivity movement downward. In particular, all of the plants in the 1976-1981 time period, 80% of the plants in the next time period, and all of the plants in the 1986-1991 period move downward in their productivity rankings. Similarly, all of the plants in rank 2 during the last period moved downward. In sum, the youngest plants cannot sustain the highest ranks (TFP rank 3 and TFP rank 2 category during the last period) and there is considerable movement in their productivity ranks.

The analysis of the plants which are in the age category 2 indicates that 75% of the plants in rank 2 from 1976 to 1981, and all of the plants in rank 0 from 1981 to 1986 stay in their initial categories. We note that there is considerable movement in age category 2 plants productivity ranks in rest of the time periods and ranks. For the plants in the age category 3 groups, considerable movement across categories is observed. Less than half of the plants stay in the same category, and most of the plants switch categories throughout the time periods. Therefore, considerable productivity movement across age and productivity groups is observed for the dairy products sub-industry.

VII. Lumpy Investment in Dairy Products Sub-Industry

This section focuses on the nature of lumpy investment at plant-level in the dairy products sub-industry. The contribution of large investment events to aggregate investments in the dairy products sub-industry over the 24-year sample period is presented in Table 9 with the contribution of the ranked investment rates based on the type of investments to cumulative aggregate investment. In Table 9, the sum of the

investment associated with each plant's largest investment episode accounts for 78% of cumulative aggregate machinery investment, 84% of cumulative aggregate buildings investment, and 76% of the combined cumulative aggregate machinery and building investments. Even in the very first investment year, each plant has already accounted for more than 75% of cumulative aggregate investment. Power's (1994) study also found that plants in the food industry completed nearly all intense periods of investment within a year, with 70.3% of food plants have a one-year spike duration and 18% of plants have a two-year spike duration. Power's study also finds that the first year of her sample has the highest percentage of observations which are investment spikes.

Table 9. Machinery, Buildings and Combined Investment Rate Analysis for each Rank

Ranks	Machinery Investment Fraction*	Mean Machinery Investment**	Buildings Investment Fraction	Mean Buildings Investment	Machinery and Buildings Investment Fraction	Mean Machinery and Buildings Investment
1	0.78367	18.7496	0.83582	14.8561	0.75604	14.8874
2	0.03604	0.8676	0.04232	0.7569	0.04262	0.8444
3	0.02679	0.6489	0.03034	0.546	0.03148	0.6276
4	0.02175	0.5269	0.02213	0.3504	0.02475	0.4935
5	0.01793	0.4344	0.01663	0.2042	0.02064	0.4115
6	0.01521	0.373	0.01235	0.2339	0.01739	0.3511
7	0.01309	0.3212	0.00917	0.1736	0.01479	0.2986
8	0.0113	0.279	0.00708	0.1109	0.01258	0.2556
9	0.00991	0.2447	0.0055	0.0777	0.01106	0.2248
10	0.00869	0.2145	0.00442	0.059	0.00964	0.1958
11	0.0078	0.1926	0.0034	0.0448	0.00837	0.17
12	0.007	0.1739	0.00269	0.049	0.00737	0.1506
13	0.00624	0.155	0.00213	0.028	0.00657	0.1343
14	0.00561	0.1394	0.00168	0.0212	0.00589	0.1205
15	0.00507	0.126	0.00132	0.0216	0.00525	0.1074
16	0.00463	0.115	0.00095	0.0131	0.00481	0.0984
17	0.00408	0.0948	0.0007	0.01	0.00433	0.0852
18	0.00362	0.091	0.00047	0.0096	0.00383	0.0788
19	0.00311	0.0705	0.00032	0.0061	0.00338	0.0666
20	0.00267	0.0642	0.00024	0.0082	0.00282	0.0555

21	0.00218	0.0531	0.00016	0.0055	0.00232	0.0465
22	0.00172	0.0403	0.00009	0.0058	0.00183	0.0358
23	0.00126	0.0358	0.00006	0.008	0.00141	0.0315
24	0.00062	0.0217	0.00001	0.0047	0.00081	0.0219

* Investment fractions for each rank is found as the sum of the investment associated with each plants' the highest (for rank 1), the second-highest (for rank 2), and so on, annual investment episode divided by the sum of each plant's total investment for the 24-year period (for example, the highest rank represents the average plant experiences a one year investment episode that accounts for 74% of its total investment spending over the 24 year interval).

** Mean Investment is calculated as: we rank investment rates for each plant from highest to lowest, such as rank 1 show the highest investment rate and 24 is the lowest, then mean investment rate shows the mean of these ranked investment rates so the rank 1 mean investment rate is the highest mean investment rate, next one shows the means of secondary largest investment rate, and so on.

There are two definitions to characterize lumpy investment spikes which are commonly considered in previous plant-level investment studies such as Power (1994), Cooper, Haltiwanger and Power (1999), and Nilsen and Schiantarelli (1998). The first definition is an absolute spike definition where the investment rate is considered to be lumpy if it exceeds a 20% change in the capital stock. As the previous studies indicate, this percentage hurdle is considered to eliminate routine maintenance expenditures implying that the lumpy investments are different from these expenditures. While this percentage hurdle is somewhat arbitrary, studies find that the results are robust compared to a variety of other definitions of investment spikes [Cooper et. al. (1999) and McClelland (1997)].

The detailed study by Power (1994) describes the relative spike definition where the plant's investment is considered lumpy if it is large relative to that plant's other investments. She defines spikes as abnormally high investment episodes relative to the typical investment rate experienced within a plant and considers various hurdles over the median investment rates (such as 1.75, 2.5, 3.5 times of median investment rate) to reflect

abnormally high investment episodes.⁶ In this study, two alternative definitions, the absolute spike definition (20%) as well as the relative spike definition [$2.5 \times (\text{median investment rate})$] are used to characterize investment behavior in the dairy products manufacturing plants.

Table 10 presents the percentage of observations in the dataset which are counted as spikes and non-spikes and the contribution of investment spikes (and non-spikes) to aggregate investments in the dairy products sub-industry according to the spike definitions. The results from this table indicate that even though the percent of observations which are lumpy investments are lower than the percentage of non-spike investment observations across investment types and spike definitions, the percentage of total sample investment accounted for by lumpy investments is significantly greater than the percentage of total investment that is not lumpy. Based on these results plant level investment is quite lumpy since a relatively small percentage of observations account for a disproportionate share of overall investment. For example, 44% (20%) of the observations are counted as machinery investment spikes, but these observations account for 95% (88%) of aggregate investment according to the absolute (relative) spike definition. A similar pattern is revealed across investment types and spike definitions.

⁶ Power (1994) indicates that absolute definition captures many smooth expansions which are ignored by the relative definition, the relative definition captures many investments which are large relative to the plants other investments, but not large in any absolute sense. An excellent extensive investigation of these alternative specifications of investment spikes and the comparisons can be found in Power (1994).

Table 10. Analysis of Investment Spike Characteristics in Dairy Products Sub-Industry across Spike Definitions and Investment Types

Machinery Investment Rate			
Spike Definitions*	Percent of Observation in Data set which are spikes and non-spikes	Number of Observations which are spikes and non-spikes	Percent Total Sample Investment Accounted for by spikes and non-spikes
Absolute Spike	44 spike 56 non-spike	1653 spike 2122 non-spike	95 spike 5 non-spike
Relative Spike	20 spike 80 non-spike	738 spike 3037 non-spike	88 spike 12 non-spike
Buildings Investment Rate			
Absolute Spike	25 spike 75 non-spike	930 spike 2845 non-spike	96 spike 4 non-spike
Relative Spike	37 spike 63 non-spike	1401 spike 2374 non-spike	99 spike 1 non-spike
Combined Machinery and Buildings Investment Rates			
Absolute Spike	40 spike 60 non-spike	1509 spike 2266 non-spike	94 spike 6 non-spike
Relative Spike	21 spike 79 non-spike	808 spike 2967 non-spike	88 spike 12 non-spike

*Absolute spike defined as investment rate that exceeds 0.20 and Relative spike defined as investment rate that exceeds $[(2.5 \times \text{median investment rate})]$.

** Percent of total sample investment accounted for by spikes is found by the ratio of investment spikes to total investment.

Additional Table Notes: Time series results of the investment spike contributions to aggregate investments and the fraction of plants that have lumpy investment episodes in each year presented in the Appendix, Table A.11.⁷

Recent findings indicate that fluctuations in aggregate investments are closely linked to the fraction of plants experiencing large investment episodes (Cooper, Haltiwanger and Power, 1999). For the dairy products sub-industry, the time series fluctuations and relative importance of large investment episodes are plotted in Figures 9-

⁷ These results indicate that, on average, plants with large machinery investment episodes constitute 42% (19%) of the plants but account for, on average, 70% (35%) of the machinery investment rate according to the absolute (relative) spike definition. Both lumpy and non-lumpy investments are important components of investment. Similarly, on average, plants with large buildings investment episodes constitute 24% (36%) of the plants but account for 73% (89%) of the buildings investment, based on absolute (relative) spike definition. Large episodes for combined machinery and buildings investments constitute, on average, 39% (21%) of plants and account 66% (39%) of the machinery and buildings investment rate based on absolute (relative) spike definition.

11 and present the time series fluctuations in the fraction of plants with investment rates in excess of 20% of their contribution to aggregate investment.⁸ The pattern of aggregate investment accounted by investment spikes closely follows the fraction of plants having investment spikes.

The fraction of plants presenting large investment episodes and the amount of investment accounted by such plants are positively correlated with the aggregate investment for both spike definitions. The correlation between the aggregate machinery investment rate and the fraction of plants with investment rates larger than $[2.5 * (\text{medium investment rate})]$ is 0.64. The correlation between the aggregate machinery investment rate and the fraction of investment accounted for by plants with investment rates larger than $[2.5 * (\text{medium investment rate})]$ is 0.55. For buildings investment rate, these correlations are 0.52 and 0.33, respectively; and, for machinery and buildings investment together it is 0.62 and 0.52, respectively. For the absolute spike definition these correlations are: for machinery 0.50 and 0.41, respectively; for buildings 0.57 and 0.38, respectively; and, for machinery and buildings together 0.50 and 0.40, respectively. The positive and strong correlations detected in machinery investment and machinery and buildings investments together for the relative spike definition indicates that the fluctuations in the aggregate investment are linked closely to the fraction of plants experiencing large investment episodes.⁹

⁸ Only the graphs based on the absolute spike definition is presented and the similar patterns that are seen in the graphs based on relative spike definition.

⁹ The correlation between aggregated investment rates, fraction of plants with investment rate and investment accounted by these plants according to spike definitions are presented in the Appendix, Tables A.12a and A.12b.

Table 11 presents the number of investment spikes per plant and percentage of plants exhibiting investment spikes over the 24-year period to analyze the lumpy structure of the dairy products sub-industry (see figures 12-13 in Appendix).¹⁰

Table 11. Number of Spikes and Percent of Plants in each Spike for Investment Types and Spike Definitions

ABSOLUTE SPIKE DEFINITION				RELATIVE SPIKE DEFINITION		
	Machinery Investment	Buildings Investment	Machinery and Buildings Investment	Machinery Investment	Buildings Investment	Machinery and Buildings Investment
SPIKES	Percent of Plants	Percent of Plants	Percent of Plants	Percent of Plants	Percent of Plants	Percent of Plants
0	98.77	98.77	98.77	98.77	98.77	98.77
1	0.61	1.23	1.23	1.23	0.61	0.61
2	1.23	4.29	0.61	4.91	0.61	6.14
3	0	7.98	0	14.11	3.07	7.36
4	0.61	13.50	1.84	28.83	3.07	20.25
5	0.61	21.47	2.45	28.22	4.91	25.15
6	3.07	17.79	3.07	17.79	12.88	27.61
7	7.36	18.41	11.66		10.43	11.04
8	9.20	6.14	14.11		15.95	
9	22.09		19.02		12.88	
10	14.11		20.25		9.20	
11	11.66		7.98		9.82	
12	11.04		9.20			
13	7.36		4.91			
14	6.14					

Almost all of the plants (99%) have at least one year without a lumpy investment episode. Based on absolute spike definition, outside of zero, machinery investment spikes ranging from 1 to 14 accounts for 95% of plants indicating every plant has at least

¹⁰ In this table, for each investment types there exist a low percentage of plants that has higher than the reported spike numbers but we don't report these numbers due to the confidentiality reasons.

one spike in any given year out of the 24-year time period.¹¹ For those plants engaged in lumpy investment ranging from 1-18 different years, the median numbers of lumpy investment episodes are 6 and 15 times. Machinery investment spikes total 9-12 times over the 24-year period and account for 59% of the plants.

For building investment spikes, outside of zero, the spikes range from 1 to 8 times over the sample period and account for 91% of plants suggesting that 9% (at most) of the plants never engage in lumpy investments. Of those plants engaged in lumpy investments ranging from 1-14 times, the median number of lumpy investment episodes are 2 and 10 times. Building investment spike episodes totaling 4-7 times over the 24-year period account for 71% of the plants. For the combined machinery and building investment spikes, outside of zero, spikes range from 1-13 times over the period, accounting for 96% of plants. Of those plants engaged in lumpy investments ranging from 1-17 times over the period, the median number of lumpy investment episodes is 5 times. The combined machinery and building investment spike episodes total 7-10 times over the 24-year period, accounting for 65% of the plants.

Based on the relative spike definition, outside of zero, machinery investment spikes range from 1 to 6 times over the sample period, accounting for 95% of plants, suggesting that 5% (at most) of plants never engage in lumpy investments. Of those plants engaged in lumpy investments ranging from 1 to 9 times over the sample period, the median number of lumpy investment episodes is 2 times. Machinery investment

¹¹ The maximum number of spikes observed are 18(9) spikes for machinery investments, 14(16) spikes for building investments, 17(10) spikes for the combined machinery and building investments based on absolute (relative) spike definition. Due to the confidentiality reasons we have only reported up to 14(6) spikes for machinery investments, 8(11) spikes for building investments and 13(7) spikes for the combined machinery and building investments based on absolute (relative) spike definition in Table 11.

spikes totaling 3-6 times over the 24-year period account for 89% of the plants. For building investment spikes, outside of zero, the spikes ranging from 1 to 11 times and account for 83% of plants suggesting that 17% (at most) of plants never engage in lumpy investments. Of those plants engaged in lumpy investments ranging from 1-16 times over the sample period, the median number of lumpy investment episodes are 12, 13 and 14 times. Building investment spike episodes, totaling 6-9 times over the 24-year period, account for 52% of the plants. For the combined machinery and building investment spikes, outside of zero, the spikes ranging from 1-7 accounts for 98% of plants. Of those plants engaged in lumpy investments ranging from 1-10 times over the sample period, the median number of lumpy investment episodes are 2 and 3 times. The combined machinery and building investment spike episodes, totaling 4-7 times over the 24-year period, account for 84% of the plants. The results, presented in table 12, also indicate that there is a high correlation between the percent of plants that has various investment rates across spike definitions.

Table 12. Correlation between Percent of Plants in each Number of Spikes for Investment Types according to Absolute and Relative Spike Definitions

	Percent of Plants for Mach. Inv. Rate According to Relative Spike Definition	Percent of Plants for Bldg. Inv. Rate According to Relative Spike Definition	Percent of Plants for Mach. & Bldg. Inv. Rate According to Relative Spike Definition
Percent of Plants for Mach. Inv. Rate According to Absolute Spike Definition	0.8661	0.9788	0.9021
Percent of Plants for Bldg. Inv. Rate According to Absolute Spike Definition	0.9644	0.9493	0.9836

Percent of Plants for Mach. & Bldg. Inv. Rate According to Absolute Spike Definition	0.8674	0.9818	0.8777
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Table 13 presents the percentage of investment spike observations in each period for various investment types and definitions and shows that for all spike definitions and investment types, the first period, specifically the year 1972, has the highest fraction of investments over the 24-year sample.

Table 13. Percentage of Observations, which are Investment Spikes by Periods for Possible Investment Types and Spike Definitions

Years in Periods	ABSOLUTE SPIKE DEFINITION			RELATIVE SPIKE DEFINITION		
	Fraction of Machinery Investment Spikes	Fraction of Building Investments Spikes	Fraction of Machinery and Building Investments Spikes	Fraction of Machinery Investment Spikes	Fraction of Building Investments Spikes	Fraction of Machinery and Building Investments Spikes
1972-75	0.338777	0.36451	0.37045	0.61111	0.266952	0.59159
1976-80	0.255293	0.26883	0.2664	0.19784	0.246967	0.21411
1981-85	0.150635	0.15483	0.15176	0.09622	0.185582	0.10643
1986-90	0.132486	0.12152	0.11597	0.06912	0.16631	0.05941
1991-95	0.122807	0.09031	0.09543	0.02575	0.13419	0.02846

Additional Table Notes: Percentage of observations which are investment spikes based on investment types and spike definitions are also represented for each year over the 24 year sample period in the Appendix, Table A.13 and figures 14-15.

There is a positive and significant correlation between fractions of various investment spikes across the two spike definitions during the specified time period (see Table 14).

Table 14. Correlation between Percentage of Observations, Which are Investment Spikes by Year for Investment Types according to Absolute and Relative Spike Definitions

	Fraction of Mach. Inv. Spikes According to Relative Spike Definition	Fraction of Bldg. Inv. Spikes According to Relative Spike Definition	Fraction of Mach.& Bldg. Inv. Spikes According to Relative Spike Definition
Fraction of Mach. Inv. Spikes According to Absolute Spike Definition	0.9279	0.9442	0.9497
Fraction of Bldg. Inv. Spikes According to Absolute Spike Definition	0.9336	0.9839	0.9522
Fraction of Mach. & Bldg. Inv. Spikes According to Absolute Spike Definition	0.9301	0.9604	0.9546

VIII. Lumpy Investment and Productivity Growth

An initial investigation into the relationship between lumpy investment and TFP growth can draw on the results of Ericson and Pakes (1995) and Pakes and McGuire (1994). Ericson and Pakes (1995) build a model to illustrate how TFP growth rates relate to investment rates. In particular, both low and high TFP growth rates suggest periods of low investment. The high mortality rates of new firms are associated with an initial learning period where most perform poorly with low levels of investment after the initial startup costs. There is a threshold of TFP growth rates when firms decrease their investment after passing the threshold. Baumol and Wolfe (1983) arrive at similar results as they explore the feedback effects of R&D investment and productivity growth rates

The relationship between R&D and investment spikes cannot be empirically evaluated in this study. However, when R&D activity is associated with changes in how a firm undertakes its production activities such changes can involve significant additions

and reorganizing of production processing and capacity which involves large changes in capital stock. Some of these changes may involve doing the same thing more extensively (i.e., extracting scale economies) and some of these changes may involve doing things differently (i.e., introducing new equipment and processes).¹² Initiatives to install additional capital may arise from a need to enhance productivity growth. However, productivity growth implies resource use decisions affecting the quantity of resources available for new production planning, in particular, and activities, in general. Thus, it is reasonable to consider the prospect that there is a simultaneous relationship between productivity growth and investment spikes. Investment spikes soon stimulate rapid growth of productivity in the sector when the spikes are associated with new technologies. But that, in turn, raises the price of investment in production capacity (and the productivity growth rate) and reduces the quantity of productive capacity demanded. In the following period productivity growth is impeded permitting a reduction in the productive capacity price stimulating demand for capacity-improving investment yet again.

While this conceptual model is highly simplified it does point out some dynamic disincentives of productive capacity investment. When productive capacity investment succeeds in increasing productivity growth, it automatically increases its own relative costs in comparison with production cost leading to a reduction in the financial incentive

¹² TFP can be decomposed into a scale effect and a technical change effect [as presented in (10)]. When an investment spike takes place, it can either expand the current plant using the same technology (a scale effect) or add new technology (the technical change effect). In the presence of decreasing returns to scale (which we find for all four TFP growth quartiles), the scale effect associated an increase in input use (capital in the case of an investment spike) leads to falling TFP. Finding a result where investment spikes lead to an increase in TFP growth implies the presence of some positive technical change. On the other hand, if investment spikes are negatively correlated with TFP growth, then the presence of decreasing returns to scale suggests the investment was not introducing new technology but rather increasing the scale of operations.

of this investment. Thus, the success of capacity-improving investment activity serves to undermine its own demand. Unfortunately, the more impressive the record of past success of capacity-improving investment activity the more strongly it tends to constrain private demand for productive capacity.

Given both the demand and supply side arguments regarding investment spikes and TFP growth rates, we investigate both impacts of investment spikes and TFP growth; namely, current investment spikes lead to higher future TFP growth rates, and higher current TFP growth rates impact the future investment spikes. We investigate two correlations. The first is the three-year average TFP growth rate centered on time t against the three-year average of the investment spikes centered on time $t-2$ (specifically, $TFP_{(t+1),t,(t-1)}$ vs. $IS_{(t-1),(t-2),(t-3)}$). The second is the three-year average TFP growth rate centered on time $t-2$ against the three-year average of the investment spikes centered on t (specifically, $TFP_{(t-1),(t-2),(t-3)}$ vs. $IS_{(t+1),t,(t-1)}$)¹³. We investigate these correlations considering various group of plants based on their TFP rankings, such as the lowest TFP ranked plants, middle ranged TFP ranked plants and the highest TFP ranked plants. Additionally, we investigate the investment spikes considering the two spike definitions (absolute and relative spikes) as well as different investment types (machinery, building and combined machinery and buildings).

Our correlation results show that the correlation between the three-year average TFP growth rate centered on time t and the three-year average of the investment spikes centered on time $t-2$ (specifically, $TFP_{(t+1),t,(t-1)}$ vs. $IS_{(t-1),(t-2),(t-3)}$) is high and positive for

¹³ We attempted two approaches to specify the three year average of investment spikes. The first approach takes the three year average of the investment spikes during those periods. The second approach considers investment spike as equal to 1 if there exist an investment spike in any of these periods, otherwise it is 0. Our results are fairly robust based on these two alternative characterizations of average investment spikes.

the middle ranged TFP ranked plants while there is no correlation for the lowest and the highest TFP ranked plants. This correlation is particularly high for the combined machinery and buildings investments. This suggests strong evidence for the Ericson and Pakes prediction.

Turning to the demand for investment spikes, the correlation between the three-year average TFP growth rate centered on time $t-2$ and the three-year average of the investment spikes centered on t (specifically, $TFP_{(t-1),(t-2),(t-3)}$ vs. $IS_{(t+1),t,(t-1)}$) is positive but not significant in magnitude for the middle ranged TFP ranked plants and no correlation for the lowest and the highest ranked plants. This results hold for investment spike definitions, absolute and relative, and for all investment types, machinery, buildings and combined machinery and buildings. Therefore, for the middle ranked dairy products manufacturing plants, investment spikes drive total factor productivity while there is no such an evidence for the highest and the lowest ranked dairy manufacturing plants. We have found similar result for the meat manufacturing plants (see Celikkol and Stefanou, CES Working Paper).

Pakes and McGuire (1994) find that investment can raise the probability of moving up in rankings. To investigate this issue, we look at the correlation between the change in TFP rankings and investment spikes for each plant by year. Our results do not show any significant correlation between the change in TFP rankings (plants' moving up in TFP rankings) and the investment spikes for the dairy products industry.

IX. Conclusions

The findings from this study are:

- i. For the TFP growth decomposition, on average, the scale effect is the most significant component of the TFP growth for the plants in TFP ranks 0, 1 and 3. The exogenous technical change effect has the most significant contribution throughout the time periods for the plants in rank 2. Plants in the lowest, middle and the highest ranks extract scale efficiencies over technological progress. For the lowest TFP ranked plants, this situation suggests that these plants cannot afford to realize higher productivity growth through technological adoption but they have the potential to reorganize input allocations to achieve productivity growth.
- ii. In the dairy products sub-industry, exogenous input bias results suggest that technical change is biased toward the capital input and toward the labor input after the 1976-1980 period. For the material input, technical change is biased against the material input except the 1981-1985 period. The direction of technical change is biased against the energy input during the 1981-1985 and 1991-1995 periods and toward the energy input during the remaining periods, averaging -2.6% throughout the years.
- iii. The time profile of productivity growth in the dairy products sub-industry for all quartile groups indicates that plants in the TFP ranks 1 and 2 follow one another closely with a small persistent gap throughout the period of study. Plants in the lowest and the highest TFP growth categories present a significant gap. The lowest ranked plants close the gap between the other

categories until 1977 and gaps between other categories remain constant after 1977 until the end of the period. Plants in the lowest TFP rank have the most fluctuating productivity growth patterns. Overall, there is a gap among all the TFP growth ranks; in particular, between the highest and the lowest TFP ranked plants. For example, while the lowest ranked plants' productivity growth averaged -1.9% , the highest ranked plants' productivity growth averages 1.1% over the time period of this study.

- iv. In the analysis of the size effect on productivity growth, plants in the middle (size category B) and middle-larger (size category C) size categories, present the highest average growth rate, on average. In each period different size categories become effective with respect to their productivity levels. Overall, the middle and middle-larger size categories present the highest TFP growth. Investigation of the technical change contribution to TFP growth across plant sizes indicates that, on average, the smallest-sized plants (size category A) have the highest technological change contribution on TFP growth in a same direction with TFP throughout the time periods. But, based on the period averages, plants in middle size category present the technical change as the dominating contribution to TFP during the 1973-75, 1986-1990 and 1991-1995 periods.
- v. The analysis investigating the number of times that plants change their productivity rankings shows that all of the plants change their productivity at

least once in the dairy products sub-industry. Considering all the age categories and the industry plants together indicate considerable movement in plants' productivity categories for this sub-industry.

- vi. Plant productivity transition tables show that in the dairy products sub-industry, generally no more than 50% of the plants stay in the same category. This indicates considerable movement between productivity rank categories for this sub-industry. The transition results based on the youngest age category indicate that less than 50% of the plants in all ranks and time periods stay in the same category indicating there is considerable movement in the youngest plants' productivity ranking. The results also indicate that the youngest plants cannot sustain the highest TFP rank (rank 3 and rank 2 category during the last period). The transition analysis for the middle-aged plants indicates that 75% of the plants in rank 2 during the 1976-1981 time period, all of the plants in rank 0 during the 1981-1986 time period stay in their initial categories except for the variation observed for remaining periods and various productivity ranks. For the plants in the oldest age group, considerable movement across TFP categories is observed. Less than half of the plants stay in the same category, and most of the plants switch categories throughout the time periods. Therefore, considerable productivity movement across age and productivity groups is observed for this sub-industry.

- vii. Each plant has already accounted for more than 75% of cumulative aggregate investment in the first investment year, 1972. As the industry exhibits a considerable number of lumpy investment episodes dominating much of the investments, it continues to present non-lumpy investment as well.
- viii. The Investment analysis results strongly suggests that plant-level investments are quite lumpy with a relatively small percent of observations accounting for a disproportionate share of overall investment. A similar characteristic of investment spikes is seen across spike definitions and investment types in the dairy products sub-industry. This finding is also clearly detected from annual contributions of the investment spikes to aggregate investments and the fraction of plants presenting lumpy investment episodes in each year. Therefore, both lumpy and non-lumpy investments are important components of investment for this industry.
- ix. Initial investigation of the impacts of investment spikes and TFP growth finds that current investment spikes lead to higher future TFP growth rates, and higher current TFP growth rates do not significantly impact the future investment spikes show for any quartile.

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APPENDIX

Table A. 1 Translog Production Function Estimation Using Fixed Effect Regression with 4-digit Industry Dummies for Dairy Products Industry*

Variables	202 Sub-Industry	
Constant	-	
Log(K)	-0.03777	(-0.99)
Log(L)	0.59952	(6.35)
Log(M)	0.49949	(6.12)
Log(E)	0.00141	(0.02)
T	0.00101	(0.14)
$[Log(K)]^2$	0.00014	(0.03)
Log(K)*Log(L)	0.00149	(0.26)
Log(K)*Log(M)	-0.00345	(-0.65)
Log(K)*Log(E)	0.00968	(1.65)
$[Log(L)]^2$	0.05754	(3.37)
Log(L)*Log(M)	-0.06603	(-4.99)
Log(L)*Log(E)	-0.01765	(-1.58)
$[Log(M)]^2$	0.04581	(4.06)
Log(M)*Log(E)	0.02506	(2.35)
$[Log(E)]^2$	-0.03029	(-2.71)
Log(K)*T	0.00397	(4.59)
Log(L)*T	-0.00088	(-0.87)
Log(M)*T	-0.00002	(-0.02)
Log(E)*T	-0.00202	(-1.85)
T^2	-0.00116	(-5.88)
R-squared	0.83	
Hausman Specification Test χ^2	210.81	[0.0000]
Breusch and Pagan LM Test χ^2	6062.57	[0.0000]
N	3748	

* T-statistics in parentheses, p-values in brackets

**Table A.2 Average TFP Growth without Ranking Plants for every year in Dairy
Products Sub-Industry**

Years	Mean TFP	Mean Scale	Mean Technical Change	Mean Returns to Scale
1973	-0.007417	-0.01206	0.004701	0.90534
1974	-0.000382	-0.00681	0.006382	0.9106
1975	0.003919	-0.00262	0.00648	0.91271
1976	-0.00178	-0.00817	0.006391	0.91429
1977	0.001614	-0.00426	0.005871	0.91575
1978	0.002113	-0.00339	0.005501	0.91796
1979	0.003664	-0.00137	0.005029	0.92077
1980	0.001658	-0.00268	0.004336	0.92209
1981	0.000016	-0.0034	0.003417	0.922
1982	0.001319	-0.00151	0.002825	0.92523
1983	-0.001112	-0.00274	0.001624	0.92475
1984	0.001163	0.000339	0.000823	0.92762
1985	-0.005358	-0.00511	-0.00025	0.9285
1986	0.000483	0.001902	-0.00143	0.92831
1987	-0.005249	-0.00298	-0.00228	0.93009
1988	-0.004938	-0.00156	-0.00338	0.9307
1989	-0.005368	-0.00107	-0.00429	0.93224
1990	-0.007894	-0.00255	-0.00535	0.93264
1991	-0.008435	-0.00203	-0.00641	0.93376
1992	-0.009207	-0.00162	-0.00759	0.9331
1993	-0.009163	-0.00041	-0.00875	0.93467
1994	-0.010855	-0.00094	-0.00992	0.93548
1995	-0.012292	-0.00138	-0.01091	0.93708

Table A.3a TFP Decomposition for Rank 0 in each Year

Years	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973	-0.042079	-0.04603	0.003952	0.89795
1974	-0.024657	-0.02985	0.005192	0.90255
1975	-0.016002	-0.02012	0.004116	0.9122
1976	-0.022429	-0.02799	0.005558	0.91048
1977	-0.014402	-0.01851	0.004107	0.91349
1978	-0.013523	-0.01892	0.005393	0.914
1979	-0.010259	-0.01399	0.003734	0.92067
1980	-0.012308	-0.01544	0.003131	0.91949
1981	-0.014491	-0.01691	0.00242	0.91967
1982	-0.01425	-0.01575	0.001497	0.92284
1983	-0.016484	-0.01657	0.000088	0.92014
1984	-0.011494	-0.01131	-0.00019	0.9247
1985	-0.022494	-0.02168	-0.00082	0.92573
1986	-0.017414	-0.01524	-0.00218	0.92487
1987	-0.022584	-0.01926	-0.00332	0.92682
1988	-0.015206	-0.01091	-0.0043	0.92903
1989	-0.017878	-0.01281	-0.00507	0.9286
1990	-0.022847	-0.01666	-0.00618	0.92884
1991	-0.020508	-0.01287	-0.00764	0.93287
1992	-0.023762	-0.01513	-0.00863	0.93107
1993	-0.022417	-0.01279	-0.00963	0.93251
1994	-0.020309	-0.00932	-0.01099	0.93208
1995	-0.026326	-0.01562	-0.0107	0.9364

Table A.3b TFP Decomposition for Rank 1 in each Year

Years	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973	-0.006299	-0.010389	0.004089	0.89892
1974	-0.000434	-0.005476	0.005042	0.90736
1975	0.000704	-0.006275	0.006979	0.91848
1976	-0.003133	-0.008411	0.005278	0.91463
1977	-0.001212	-0.006462	0.00525	0.91457
1978	-0.000047	-0.003789	0.003742	0.92239
1979	0.002094	-0.002229	0.004322	0.92062
1980	0.000869	-0.002563	0.003433	0.9195
1981	-0.001905	-0.00513	0.003225	0.92005
1982	-0.001274	-0.003445	0.002171	0.92455
1983	-0.002289	-0.004119	0.00183	0.93043
1984	-0.002359	-0.002687	0.000328	0.92704
1985	-0.006342	-0.004914	-0.00143	0.93104
1986	-0.005216	-0.003216	-0.002	0.93139
1987	-0.005635	-0.003171	-0.00246	0.92452
1988	-0.006764	-0.002844	-0.00392	0.93162
1989	-0.006962	-0.002476	-0.00449	0.93613
1990	-0.009377	-0.003943	-0.00543	0.93063
1991	-0.010411	-0.00417	-0.00624	0.93445
1992	-0.010797	-0.002797	-0.008	0.94052
1993	-0.011722	-0.00291	-0.00881	0.93226
1994	-0.012589	-0.00186	-0.01073	0.93897
1995	-0.013517	-0.001761	-0.01176	0.93992

Table A.3c TFP Decomposition for Rank 2 in each Year

Years	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973	0.003346	-0.00191	0.005258	0.90884
1974	0.006048	-0.0019	0.007947	0.91819
1975	0.00677	-4.8E-05	0.006818	0.90668
1976	0.004009	-0.00304	0.007051	0.91635
1977	0.005178	-0.00172	0.006901	0.91559
1978	0.005814	-0.00065	0.006464	0.91949
1979	0.007338	0.001699	0.00564	0.92096
1980	0.005131	0.000507	0.004624	0.92304
1981	0.00316	-0.0009	0.004063	0.92838
1982	0.00418	0.000594	0.003586	0.92956
1983	0.002245	-0.00027	0.002517	0.92591
1984	0.002103	0.000835	0.001268	0.9297
1985	-0.000791	-0.00148	0.000693	0.92708
1986	-0.000818	-3.6E-05	-0.00078	0.9338
1987	-0.001042	0.00079	-0.00183	0.93408
1988	-0.003823	-0.00084	-0.00298	0.92931
1989	-0.002495	0.001264	-0.00376	0.93208
1990	-0.004765	-0.00047	-0.0043	0.93543
1991	-0.005475	0.000534	-0.00601	0.93507
1992	-0.006497	0.000918	-0.00742	0.93314
1993	-0.007482	0.000791	-0.00827	0.93544
1994	-0.009538	7.24E-05	-0.00961	0.93631
1995	-0.010643	-0.00039	-0.01025	0.9389

Table A.3d TFP Decomposition for Rank 3 in each Year

Years	TFP Growth	Scale Effect	Technical Change Effect	Average Returns to Scale
1973	0.015054	0.009786	0.005267	0.91494
1974	0.017347	0.009811	0.007536	0.91384
1975	0.02413	0.015893	0.008238	0.9142
1976	0.014284	0.006625	0.007659	0.91567
1977	0.016481	0.009299	0.007183	0.9193
1978	0.015808	0.009388	0.00642	0.9161
1979	0.015481	0.00906	0.006422	0.92084
1980	0.012941	0.006785	0.006156	0.92632
1981	0.013218	0.009275	0.003943	0.91973
1982	0.016221	0.012209	0.004011	0.92391
1983	0.011688	0.009667	0.002021	0.9224
1984	0.01647	0.014583	0.001887	0.92902
1985	0.008099	0.007532	0.000567	0.93011
1986	0.025566	0.026284	-0.00072	0.92368
1987	0.008156	0.009647	-0.00149	0.93439
1988	0.006014	0.008354	-0.00234	0.93288
1989	0.00579	0.009698	-0.00391	0.93207
1990	0.005373	0.010873	-0.0055	0.93562
1991	0.002629	0.00839	-0.00576	0.93261
1992	0.00416	0.010473	-0.00631	0.92769
1993	0.00497	0.013264	-0.00829	0.93848
1994	-0.00099	0.007346	-0.00833	0.93456
1995	0.001306	0.012239	-0.01093	0.93297

Table A.4 Exogenous Input Bias for each year

Years	Capital Input	Labor Input	Material Input	Energy Input
1973	-0.3456	-0.03287	-0.01861	0.30768
1974	-0.06832	-0.00947	-0.00559	0.22929
1975	0.59563	-0.01795	0.000479	-0.17657
1976	0.41436	-0.08692	-0.00143	0.31793
1977	0.11619	0.0819	-0.00231	-0.20781
1978	0.22377	-0.01707	-0.00262	0.10002
1979	0.16546	0.00889	-0.00254	-0.02696
1980	0.14598	0.00283	-0.00261	0.1587
1981	0.15027	-0.02705	0.001138	-0.03394
1982	0.09983	0.03862	-0.00076	-0.07667
1983	0.12182	0.73242	0.002928	-0.2068
1984	0.08159	0.0168	-0.00199	0.06969
1985	0.08812	-0.06307	0.006488	-0.14576
1986	0.08889	0.01891	-0.00119	0.03674
1987	0.06876	0.84303	-0.00321	0.36277
1988	0.0658	0.01899	-0.00118	-0.13652
1989	0.06276	0.39372	-0.00356	0.09598
1990	0.05699	0.00652	0.00042	-0.26322
1991	0.04938	-0.0382	-0.00086	0.17162
1992	0.05941	-0.00826	-0.00111	-0.59931
1993	0.05071	-0.28625	0.000731	-0.14693
1994	0.04926	0.04561	0.000928	-0.33991
1995	0.04939	0.56291	-0.00522	-0.09115

A.5 Direct Size Effect on TFP growth Decomposition (Tables A.5a-A.5d)

Table A.5a SIZE CATEGORY A (The Smallest Size Category)

Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.000413	-0.00365	0.004061	0.93354
1976-1980	-0.00045	-0.00396	0.003504	0.93885
1981-1985	-0.00167	-0.00197	0.000301	0.94636
1986-1990	-0.00572	-0.00087	-0.00485	0.9514
1991-1995	-0.01155	-0.00127	-0.01028	0.9554
1973-1995	-0.00416	-0.00223	-0.00193	0.946117

Table A.5b SIZE CATEGORY B (Middle Size Category)

Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.000255	-0.00495	0.005119	0.91774
1976-1980	0.001985	-0.00343	0.005413	0.92753
1981-1985	-0.00064	-0.00183	0.001192	0.93411
1986-1990	-0.00377	-0.00019	-0.00357	0.94036
1991-1995	-0.00946	-0.00033	-0.00913	0.94479
1973-1995	-0.00255	-0.0019	-0.00066	0.934225

Table A.5c SIZE CATEGORY C (Middle-Larger Size Category)

Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.00058	-0.00663	0.006057	0.89916
1976-1980	0.003255	-0.00228	0.005533	0.90974
1981-1985	-0.00071	-0.00284	0.002137	0.91898
1986-1990	-0.00488	-0.00213	-0.00276	0.92377
1991-1995	-0.00943	-0.00135	-0.00808	0.9288
1973-1995	-0.00263365	-0.00274	0.0001	0.917561

Table A.5d SIZE CATEGORY D (The Largest Size Category)

Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.00514	-0.01322	0.008112	0.88859
1976-1980	0.00102	-0.00623	0.007248	0.89694
1981-1985	-0.00016	-0.00328	0.003116	0.90316
1986-1990	-0.00405	-0.00184	-0.00221	0.90769
1991-1995	-0.00953	-0.00215	-0.00738	0.91027
1973-1995	-0.00344	-0.00466	0.001227	0.90244

A.6 Secondary Decomposition of TFP Growth based on Size Categories

(Tables A.6a-4.A.6d)

Table A. 6a TFP RANK 0

SIZE CATEGORY A				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.02316	-0.02479	0.001629	0.92657
1976-1980	-0.01525	-0.01723	0.001976	0.93334
1981-1985	-0.0132	-0.01136	-0.00184	0.94323
1986-1990	-0.01543	-0.00945	-0.00597	0.95055
1991-1995	-0.02335	-0.01173	-0.01162	0.95425
1973-1995	-0.017632957	-0.01405	-0.00358	0.942894
SIZE CATEGORY B				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.02141	-0.02478	0.003372	0.91133
1976-1980	-0.01528	-0.01894	0.003661	0.92421
1981-1985	-0.01405	-0.01425	0.0002	0.92976
1986-1990	-0.01868	-0.01433	-0.00434	0.93688
1991-1995	-0.02338	-0.01382	-0.00956	0.94517
1973-1995	-0.01831109	-0.01656713	-0.00174	0.931048
SIZE CATEGORY C				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.02562	-0.03057	0.004953	0.8935
1976-1980	-0.01157	-0.01651	0.004939	0.91036
1981-1985	-0.01393	-0.01501	0.001088	0.91678
1986-1990	-0.01889	-0.01508	-0.00381	0.92226
1991-1995	-0.0233	-0.01447	-0.00884	0.92542
1973-1995	-0.018055	-0.01726	-0.00079	0.915419
SIZE CATEGORY D				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.04119	-0.04883	0.007645	0.88648
1976-1980	-0.01649	-0.02333	0.006843	0.8956
1981-1985	-0.0225	-0.02538	0.002873	0.90108
1986-1990	-0.02345	-0.02056	-0.00289	0.90267
1991-1995	-0.02066	-0.01242	-0.00824	0.90869
1973-1995	-0.02344	-0.02413	0.000689	0.899985

Table A.6b TFP RANK 1

SIZE CATEGORY A				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.00217	-0.00445	0.002286	0.92656
1976-1980	-0.00018	-0.00237	0.002193	0.94453
1981-1985	-0.00328	-0.00296	-0.00032	0.94784
1986-1990	-0.00709	-0.00181	-0.00527	0.95354
1991-1995	-0.01173	-0.00116	-0.01057	0.95849
1973-1995	-0.005123565	-0.00239	-0.00274	0.947899
SIZE CATEGORY B				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.002	-0.00737	0.005365	0.9183
1976-1980	-0.00013	-0.00507	0.004938	0.92765
1981-1985	-0.00273	-0.00356	0.000823	0.93501
1986-1990	-0.00669	-0.00292	-0.00377	0.94025
1991-1995	-0.01189	-0.0025	-0.00938	0.94373
1973-1995	-0.00492278	-0.00401439	-0.00091	0.934266
SIZE CATEGORY C				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.00208	-0.00823	0.006151	0.90129
1976-1980	-0.0005	-0.00459	0.004097	0.9093
1981-1985	-0.00262	-0.00407	0.001453	0.92169
1986-1990	-0.00645	-0.00321	-0.00323	0.92643
1991-1995	-0.01167	-0.0025	-0.00917	0.9295
1973-1995	-0.00488587	-0.0042	-0.00069	0.919065
SIZE CATEGORY D				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	-0.00181	-0.00918	0.00737	0.88869
1976-1980	-0.00033	-0.0065	0.00617	0.8945
1981-1985	-0.00275	-0.00554	0.002787	0.90407
1986-1990	-0.00697	-0.00447	-0.00249	0.90511
1991-1995	-0.01195	-0.00451	-0.00744	0.91882
1973-1995	-0.00502	-0.00577	0.000749	0.903417

Table A.6c TFP RANK 2

SIZE CATEGORY A				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.005711	0.001153	0.004558	0.93654
1976-1980	0.005135	0.000335	0.0048	0.94159
1981-1985	0.002172	0.000658	0.001514	0.95014
1986-1990	-0.00269	0.001508	-0.00419	0.95084
1991-1995	-0.00797	0.001055	-0.00903	0.95598
1973-1995	1.56957E-05	0.000923	-0.00091	0.947928
SIZE CATEGORY B				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.005197	-0.0004	0.005592	0.91811
1976-1980	0.005519	-0.00081	0.006334	0.92827
1981-1985	0.002202	3.68E-05	0.002165	0.9386
1986-1990	-0.00254	0.000534	-0.00307	0.94246
1991-1995	-0.00795	0.000867	-0.00882	0.94784
1973-1995	7.6913E-05	8.3942E-05	-7E-06	0.936529
SIZE CATEGORY C				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.005618	-0.00168	0.0073	0.90616
1976-1980	0.005728	-0.00026	0.005987	0.91115
1981-1985	0.002014	-0.00079	0.0028	0.92061
1986-1990	-0.0026	-0.00059	-0.00202	0.92774
1991-1995	-0.00805	0.000115	-0.00817	0.92931
1973-1995	9.95652E-05	-0.00055	0.000648	0.920107
SIZE CATEGORY D				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.005085	-0.004	0.009087	0.88587
1976-1980	0.005574	-0.00177	0.007347	0.8972
1981-1985	0.002326	-0.00083	0.003151	0.90493
1986-1990	-0.00252	-0.00085	-0.00167	0.91107
1991-1995	-0.00775	-0.00047	-0.00729	0.91128
1973-1995	0.000148	-0.00137	0.001521	0.903477

Table A.6d TFP RANK 3

SIZE CATEGORY A				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.016295	0.010621	0.005673	0.93639
1976-1980	0.015776	0.010239	0.005537	0.94062
1981-1985	0.012236	0.010748	0.001488	0.94573
1986-1990	0.005502	0.009621	-0.00412	0.94959
1991-1995	0.003766	0.013426	-0.00966	0.95587
1973-1995	0.01022987	0.010958	-0.00073	0.946445
SIZE CATEGORY B				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.018443	0.011111	0.007332	0.92703
1976-1980	0.013974	0.007715	0.006259	0.92675
1981-1985	0.010627	0.008656	0.001972	0.93354
1986-1990	0.006791	0.00986	-0.00307	0.94016
1991-1995	0.001126	0.009195	-0.00807	0.9429
1973-1995	0.00947487	0.00915048	0.000324	0.934689
SIZE CATEGORY C				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.01845	0.011709	0.006741	0.90535
1976-1980	0.015194	0.008302	0.006892	0.91339
1981-1985	0.014442	0.011786	0.002656	0.92174
1986-1990	0.011565	0.014114	-0.00255	0.92762
1991-1995	0.003276	0.011059	-0.00778	0.92933
1973-1995	0.012075348	0.011367	0.000709	0.920716
SIZE CATEGORY D				
Time Period	Mean TFP	Mean Scale	Mean Technical Change	Average Returns to Scale
1973-1975	0.021901	0.013632	0.008269	0.88885
1976-1980	0.015131	0.00687	0.008261	0.89992
1981-1985	0.015354	0.011561	0.003792	0.90016
1986-1990	0.017093	0.018615	-0.00152	0.91081
1991-1995	0.001602	0.007937	-0.00634	0.90673
1973-1995	0.013548	0.011557	0.001991	0.902377

Table A.7 Plants' Productivity Transitions between Categories across Time Periods

		1981			
		Rank 0	Rank 1	Rank 2	Rank 3
1976	Rank 0	0.29	0.26	0.18	0.26
	Rank 1	0.32	0.32	0.21	0.16
	Rank 2	0.10	0.18	0.38	0.33
	Rank 3	0.32	0.26	0.24	0.18
		1986			
		Rank 0	Rank 1	Rank 2	Rank 3
1981	Rank 0	0.26	0.23	0.18	0.33
	Rank 1	0.21	0.23	0.21	0.33
	Rank 2	0.23	0.28	0.31	0.18
	Rank 3	0.31	0.25	0.31	0.14
		1991			
		Rank 0	Rank 1	Rank 2	Rank 3
1986	Rank 0	0.26	0.24	0.24	0.26
	Rank 1	0.18	0.24	0.29	0.29
	Rank 2	0.24	0.34	0.26	0.16
	Rank 3	0.26	0.21	0.24	0.29

**Table A.8 Plants' Productivity Transitions between Categories across Time Periods
based on Age Category 1**

		1981			
		Rank 0	Rank 1	Rank 2	Rank 3
1976	Rank 0	0.11	0.44	0.22	0.22
	Rank 1	0.57	0.29	0.14	0
	Rank 2	0	0.4	0	0.6
	Rank 3	0.2	0.4	0.4	0
		1986			
		Rank 0	Rank 1	Rank 2	Rank 3
1981	Rank 0	0.17	0.17	0	0.67
	Rank 1	0.2	0.4	0	0.4
	Rank 2	0.2	0.2	0.4	0.2
	Rank 3	0.2	0.4	0.2	0.2
		1991			
		Rank 0	Rank 1	Rank 2	Rank 3
1986	Rank 0	0.2	0	0.4	0.4
	Rank 1	0	0.25	0.38	0.38
	Rank 2	0.67	0.33	0	0
	Rank 3	0.2	0.2	0.4	0.2

**Table A.9 Plants' Productivity Transitions between Categories across Time Periods
based on Age Category 2**

		1981			
		Rank 0	Rank 1	Rank 2	Rank 3
1976	Rank 0	0.25	0.25	0.25	0.25
	Rank 1	0.25	0.25	0.25	0.25
	Rank 2	0	0	0.75	0.25
	Rank 3	0	0.33	0.67	0
		1986			
		Rank 0	Rank 1	Rank 2	Rank 3
1981	Rank 0	1	0	0	0
	Rank 1	0.67	0	0	0.33
	Rank 2	0.14	0.14	0.29	0.43
	Rank 3	0	0	0.67	0.33
		1991			
		Rank 0	Rank 1	Rank 2	Rank 3
1986	Rank 0	0	0.2	0.4	0.4
	Rank 1	1	0	0	0
	Rank 2	0.5	0	0.5	0
	Rank 3	0.6	0.2	0.2	0

**Table A.10 Plants' Productivity Transitions between Categories across Time
Periods based on Age Category 3**

		1981			
1976		Rank 0	Rank 1	Rank 2	Rank 3
	Rank 0	0.36	0.2	0.16	0.28
	Rank 1	0.26	0.33	0.22	0.19
	Rank 2	0.13	0.17	0.40	0.30
	Rank 3	0.37	0.23	0.17	0.23
		1986			
1981		Rank 0	Rank 1	Rank 2	Rank 3
	Rank 0	0.23	0.26	0.23	0.29
	Rank 1	0.15	0.19	0.31	0.31
	Rank 2	0.26	0.33	0.30	0.11
	Rank 3	0.36	0.25	0.29	0.11
		1991			
1986		Rank 0	Rank 1	Rank 2	Rank 3
	Rank 0	0.32	0.29	0.18	0.21
	Rank 1	0.21	0.24	0.28	0.28
	Rank 2	0.16	0.39	0.26	0.19
	Rank 3	0.22	0.22	0.17	0.39

Table A.11 Time Series Contributions of Investment Spikes to Aggregate Investments based on Investment Types and Spike Definitions

	Absolute Spike Definition						<i>Relative Spike Definition</i>					
Years	Percent of Plants having Mach. Inv. Spikes	Percent of Total Inv. accounted for by Mach. Inv. Spikes	Percent of Plants having Bldg. Inv. Spikes	Percent of Total Inv. accounted for by Bldg. Inv. Spikes	Percent of Plants having Mach. & Bldg. Inv. Spikes	Percent of Total Inv. accounted for by Mach. & Bldg. Inv. Spikes	Percent of Plants having Mach. Inv. Spikes	Percent of Total Inv. accounted for by Mach. Inv. Spikes	Percent of Plants having Bldg. Inv. Spikes	Percent of Total Inv. accounted for by Bldg. Inv. Spikes	Percent of Plants having Mach. & Bldg. Inv. Spikes	Percent of Total Inv. accounted for by Mach. & Bldg. Inv. Spikes
72	0.93	1.00	0.63	1.00	0.93	1.00	0.93	1.00	0.64	1.00	0.93	1.00
73	0.91	1.00	0.54	0.99	0.93	1.00	0.90	0.99	0.56	1.00	0.91	1.00
74	0.88	0.98	0.53	0.96	0.87	0.98	0.63	0.82	0.61	0.99	0.68	0.87
75	0.72	0.92	0.37	0.91	0.71	0.91	0.31	0.55	0.48	0.98	0.40	0.65
76	0.64	0.90	0.34	0.88	0.58	0.86	0.24	0.49	0.45	0.97	0.27	0.55
77	0.55	0.87	0.29	0.88	0.56	0.88	0.23	0.49	0.39	0.96	0.28	0.56
78	0.52	0.81	0.30	0.85	0.48	0.78	0.18	0.43	0.43	0.95	0.20	0.45
79	0.44	0.78	0.36	0.88	0.45	0.79	0.13	0.35	0.48	0.96	0.21	0.49
80	0.44	0.75	0.25	0.80	0.39	0.72	0.11	0.30	0.37	0.92	0.10	0.31
81	0.34	0.70	0.21	0.76	0.34	0.70	0.12	0.36	0.33	0.90	0.12	0.36
82	0.36	0.73	0.20	0.78	0.36	0.74	0.10	0.34	0.37	0.93	0.16	0.45
83	0.27	0.62	0.15	0.69	0.21	0.54	0.07	0.25	0.29	0.89	0.07	0.27
84	0.30	0.62	0.16	0.69	0.27	0.60	0.06	0.19	0.30	0.87	0.08	0.27
85	0.25	0.63	0.15	0.71	0.23	0.60	0.08	0.31	0.30	0.88	0.09	0.35
86	0.20	0.55	0.13	0.62	0.18	0.51	0.07	0.29	0.29	0.88	0.06	0.26
87	0.29	0.61	0.12	0.61	0.20	0.50	0.04	0.15	0.28	0.85	0.06	0.19
88	0.24	0.56	0.17	0.67	0.21	0.51	0.05	0.18	0.31	0.88	0.05	0.18
89	0.30	0.64	0.15	0.62	0.25	0.57	0.08	0.27	0.31	0.85	0.06	0.21
90	0.31	0.65	0.12	0.56	0.23	0.55	0.07	0.21	0.25	0.82	0.07	0.24
91	0.25	0.52	0.13	0.63	0.20	0.47	0.02	0.09	0.23	0.80	0.02	0.09
92	0.30	0.61	0.09	0.48	0.18	0.47	0.02	0.12	0.25	0.80	0.04	0.19
93	0.26	0.53	0.11	0.57	0.19	0.45	0.04	0.13	0.22	0.81	0.02	0.09
94	0.22	0.47	0.09	0.47	0.16	0.42	0.01	0.05	0.22	0.76	0.02	0.11
95	0.22	0.48	0.10	0.54	0.15	0.41	0.02	0.09	0.23	0.78	0.02	0.12
Mean	0.42	0.70	0.24	0.73	0.39	0.66	0.19	0.35	0.36	0.89	0.21	0.39

Table A.12a Correlation between Aggregated Investment Rate and Fraction of Plants with Spiky Investment Rate according to Spike Definitions

	ABSOLUTE SPIKE DEFINITION			RELATIVE SPIKE DEFINITION		
	Aggregate Mach. Inv. Rate	Aggregate Bldg. Inv. Rate	Aggregate Mach.& Bldg. Inv. Rate	Aggregate Mach. Inv. Rate	Aggregate Bldg. Inv. Rate	Aggregate Mach.& Bldg. Inv. Rate
Fraction of Plants with Spiky Mach. Inv. Rate	0.5016	0.4964	0.5104	0.6409	0.6340	0.6491
Fraction of Plants with Spiky Bldg. Inv. Rate	0.5721	0.5684	0.5805	0.5193	0.5168	0.5275
Fraction of Plants with Spiky Mach. & Bldg. Inv. Rate	0.4953	0.4904	0.5043	0.6100	0.6036	0.6186

Table A.12b Correlation between Aggregated Investment Rate and Investment Accounted by the Plants that have Spiky Investments according to Spike Definitions

	ABSOLUTE SPIKE DEFINITION			RELATIVE SPIKE DEFINITION		
	Aggregate Mach. Inv. Rate	Aggregate Bldg. Inv. Rate	Aggregate Mach.& Bldg. Inv. Rate	Aggregate Mach. Inv. Rate	Aggregate Bldg. Inv. Rate	Aggregate Mach.& Bldg. Inv. Rate
Mach. Inv. Accounted by Spiky Inv. Plants	0.4054	0.4017	0.4139	0.5527	0.5471	0.5614
Bldg. Inv. Accounted by Spiky Inv. Plants	0.3809	0.3791	0.3892	0.3324	0.3312	0.3404
Mach. & Bldg. Inv. Accounted by Spiky Inv. Plants	0.3956	0.3926	0.4042	0.5152	0.5105	0.5241

Table A.13 Percentage of Observations, which are Investment Spikes by Year for Possible Investment Types and Spike Definitions

ABSOLUTE SPIKE DEFINITION				RELATIVE SPIKE DEFINITION		
Years	Fraction of Machinery Investment Spikes	Fraction of Buildings Investment Spikes	Fraction of Machinery and Buildings Investment Spikes	Fraction of Machinery Investment Spikes	Fraction of Buildings Investment Spikes	Fraction of Machinery and Buildings Investment Spikes
1972	0.091954	0.11075	0.10073	0.20596	0.074946	0.18812
1973	0.089534	0.09462	0.10007	0.19783	0.064954	0.18441
1974	0.086509	0.09355	0.09344	0.13821	0.070664	0.13738
1975	0.07078	0.06559	0.07621	0.06911	0.056388	0.08168
1976	0.063521	0.05914	0.06229	0.05285	0.052106	0.05446
1977	0.054446	0.05054	0.06097	0.05149	0.045682	0.05693
1978	0.050817	0.05269	0.05169	0.04065	0.049964	0.0396
1979	0.043557	0.06237	0.04904	0.02846	0.056388	0.04208
1980	0.042952	0.04409	0.04241	0.02439	0.042827	0.02104
1981	0.033878	0.03763	0.03645	0.0271	0.038544	0.02475
1982	0.035693	0.03548	0.0391	0.02304	0.042827	0.03218
1983	0.026618	0.02688	0.02253	0.01626	0.034261	0.01485
1984	0.029643	0.02796	0.02916	0.0122	0.034975	0.01609
1985	0.024803	0.02688	0.02452	0.01762	0.034975	0.01856
1986	0.019964	0.02366	0.01988	0.01626	0.033547	0.01238
1987	0.028433	0.02151	0.02187	0.00949	0.03212	0.01114
1988	0.023593	0.03011	0.02253	0.01084	0.036403	0.0099
1989	0.029643	0.02581	0.02651	0.01762	0.035689	0.01114
1990	0.030853	0.02043	0.02518	0.01491	0.028551	0.01485
1991	0.024198	0.02258	0.02121	0.00542	0.02641	0.00495
1992	0.029643	0.01505	0.01988	0.00542	0.029265	0.00866
1993	0.025408	0.01935	0.02054	0.00813	0.025696	0.00495
1994	0.021779	0.01505	0.01723	0.00271	0.025696	0.00495
1995	0.021779	0.01828	0.01657	0.00407	0.027123	0.00495

Figure 1. Average TFP Growth in Dairy Products Sub-Industry

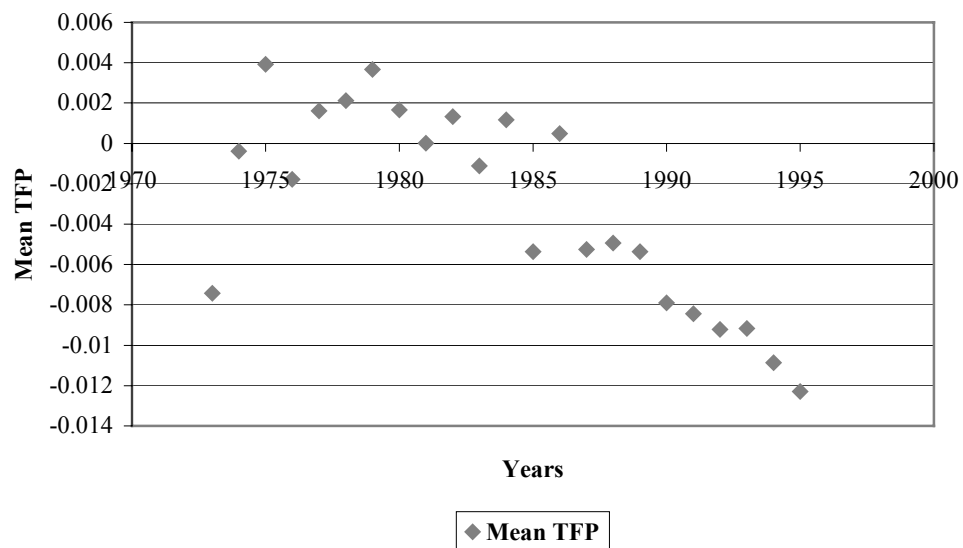


Figure 2. Mean Residuals in Dairy Products Sub-Industry

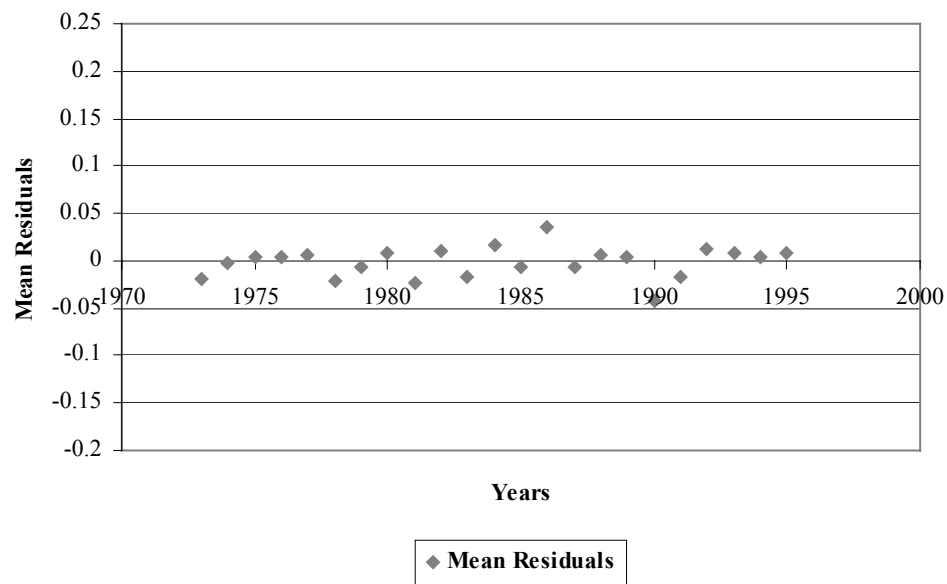


Figure 3. All Ranked TFP Together in Dairy Products Sub-Industry

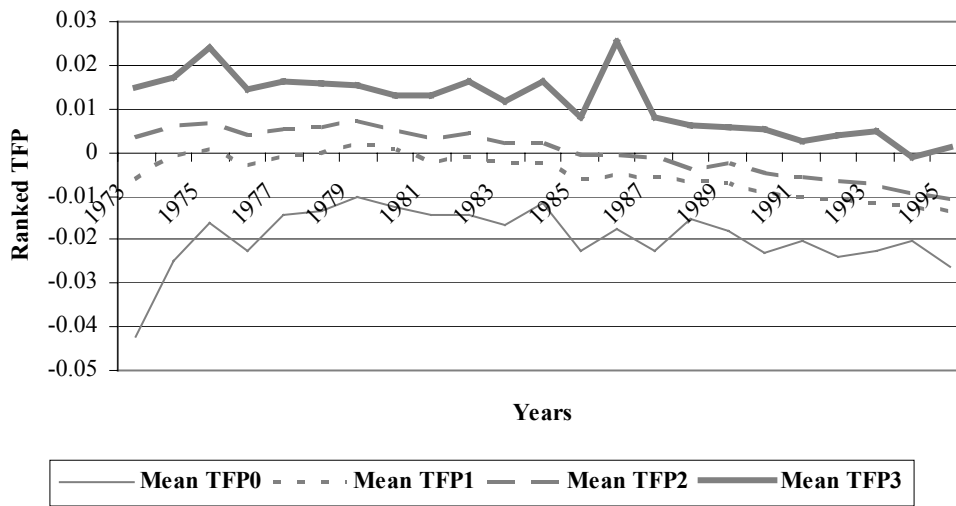


Figure 4. TFP, Scale and Technical Change Effects in Dairy Products Sub-Industry for Rank 0

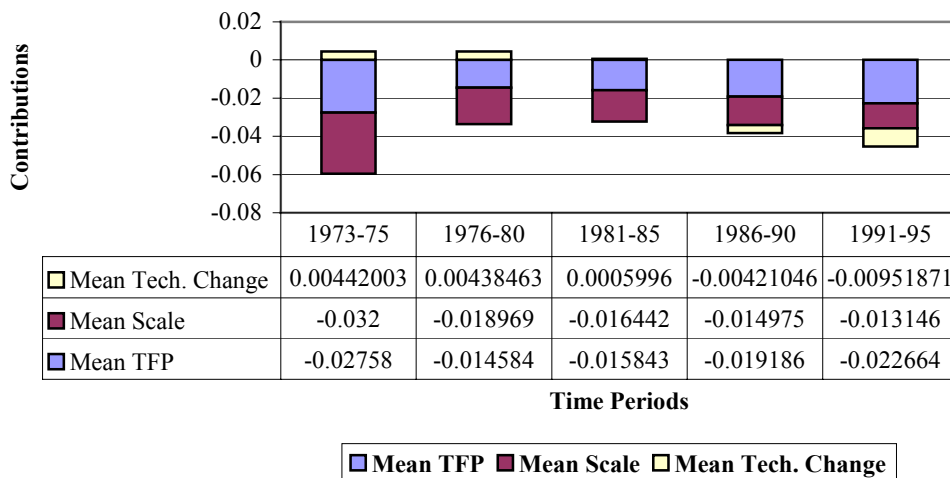


Figure 5. TFP, Scale and Technical Change Effects in Dairy Products Sub-Industry for Rank 1

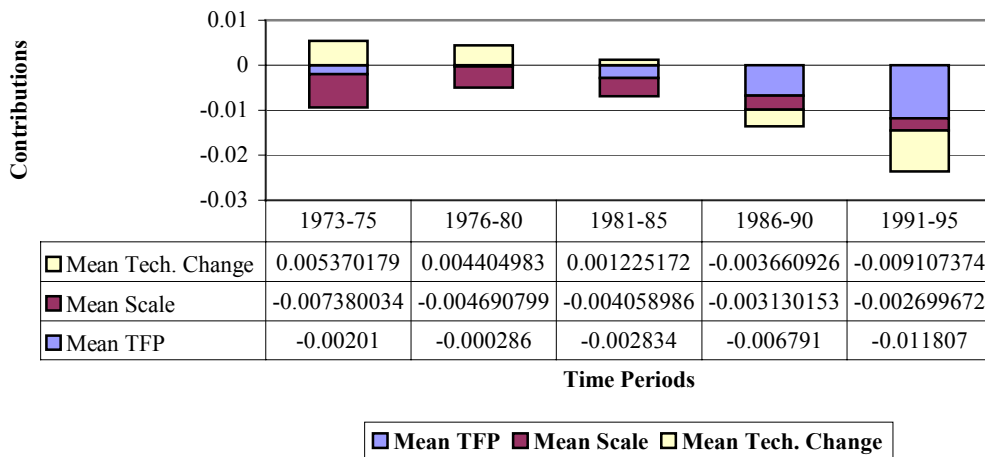


Figure 6. TFP, Scale and Technical Change Effects in Dairy Products Sub-Industry for Rank 2

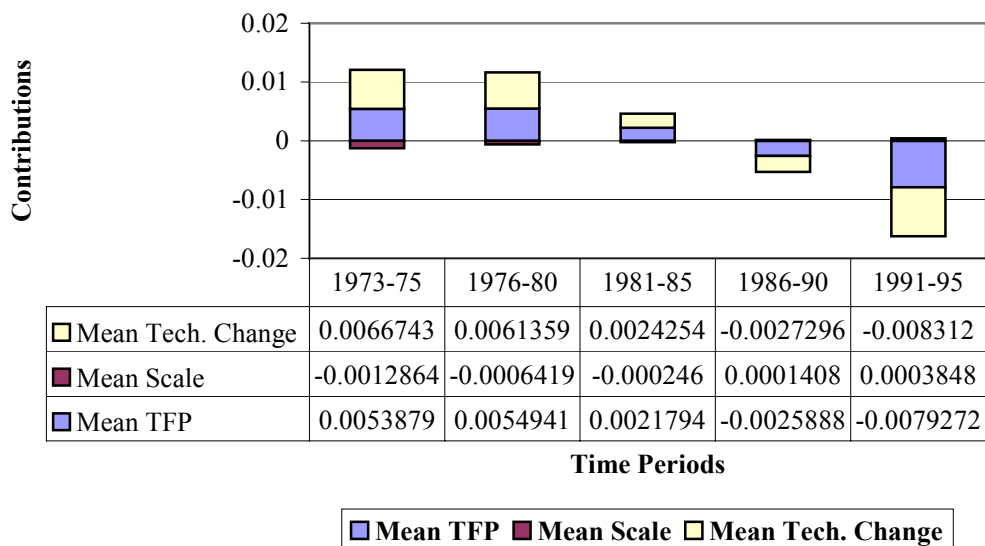


Figure 7. TFP, Scale and Technical Change Effects in Dairy Products Sub-Industry for Rank 3

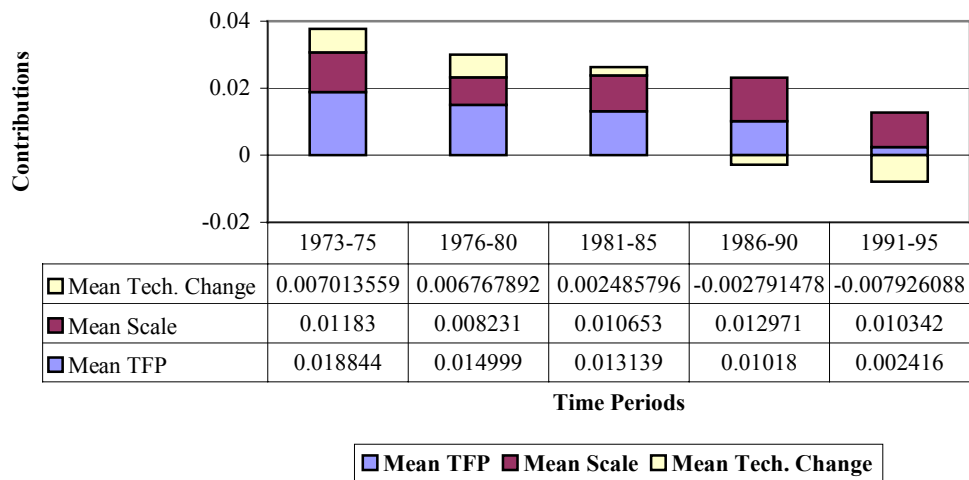


Figure 8. Average Input Bias for Dairy Products Sub-Industry

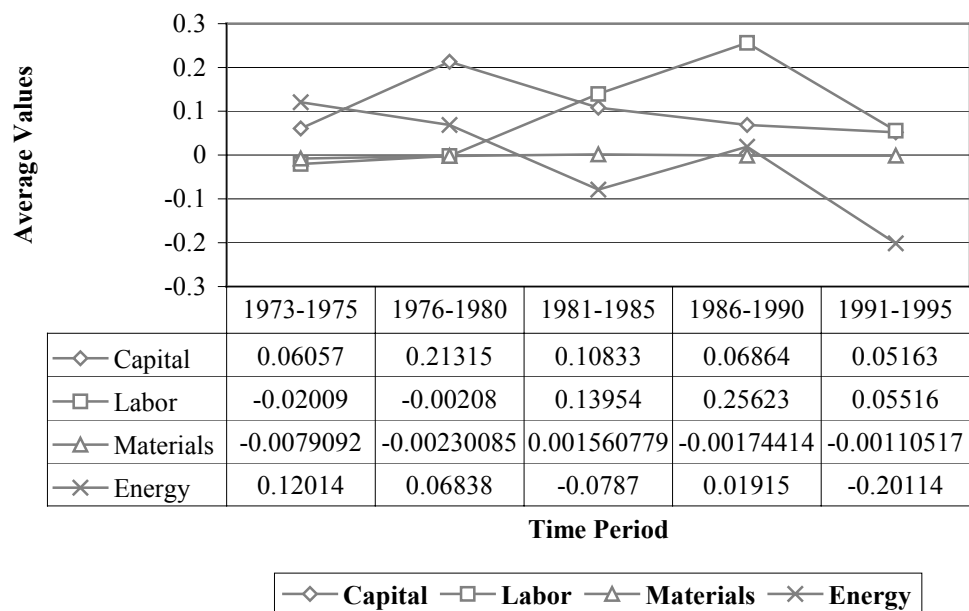


Figure 9. Investment Rate vs. Machinery Investment Spikes in Dairy Products Sub-Industry

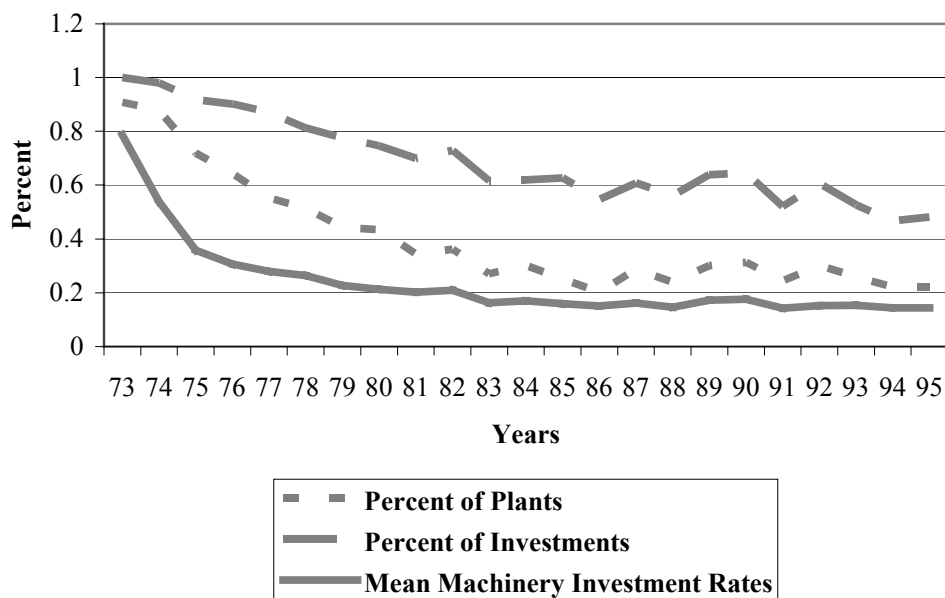
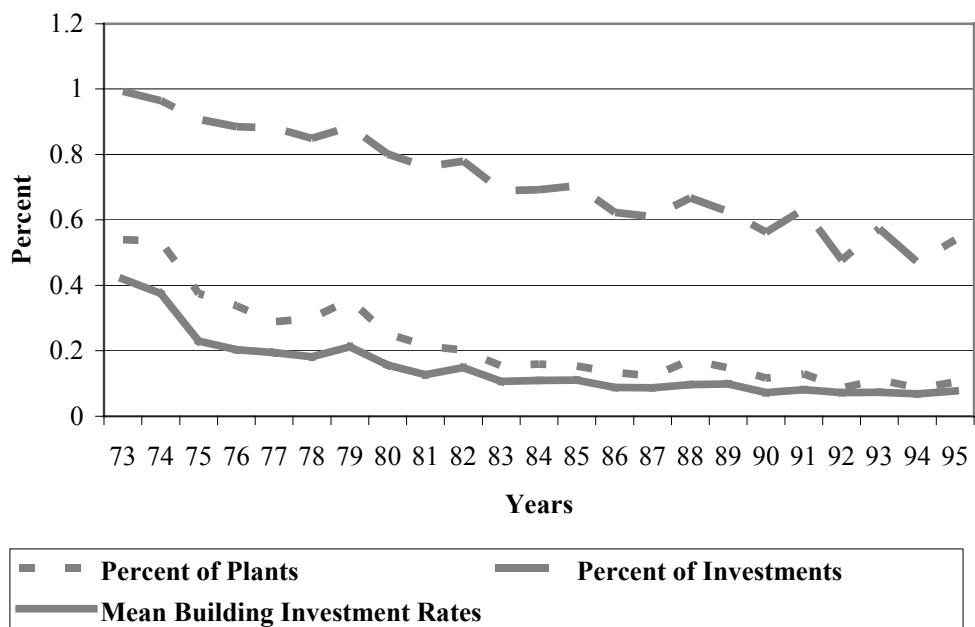


Figure 10. Investment Rate vs. Building Investment Spikes in Dairy Products Sub-Industry



**Figure 11. Investment Rate vs. Machinery and Building Investment
Spikes in Dairy Products Sub-Industry**

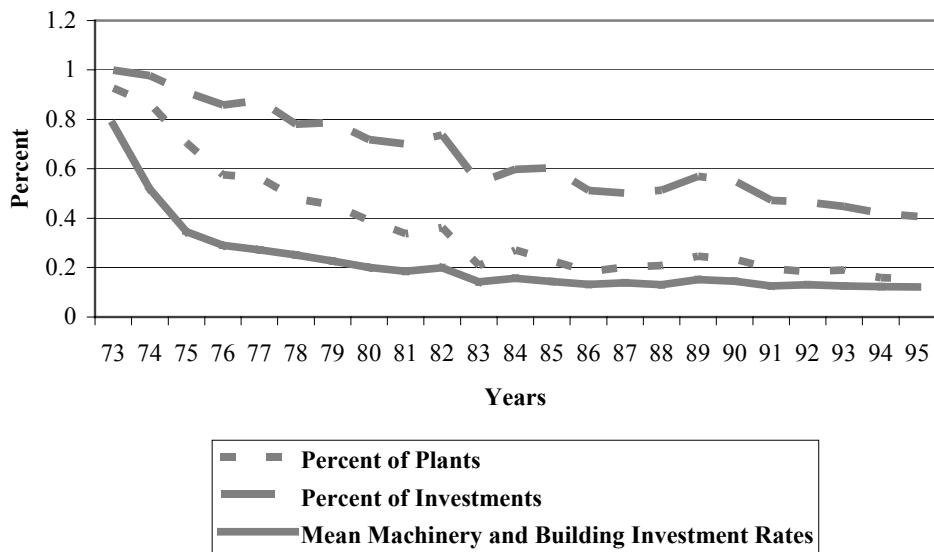


Figure 12. Absolute Spike Number for Machinery, Building and Combined Machinery and Buildings Investment Rates

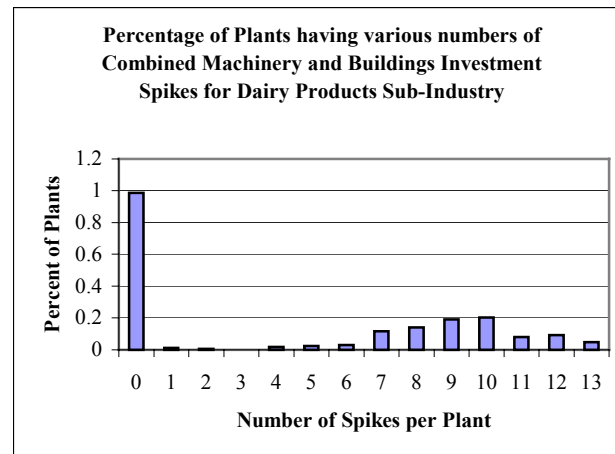
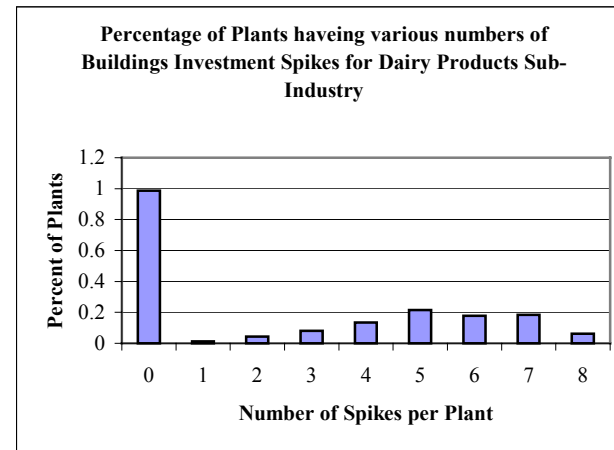
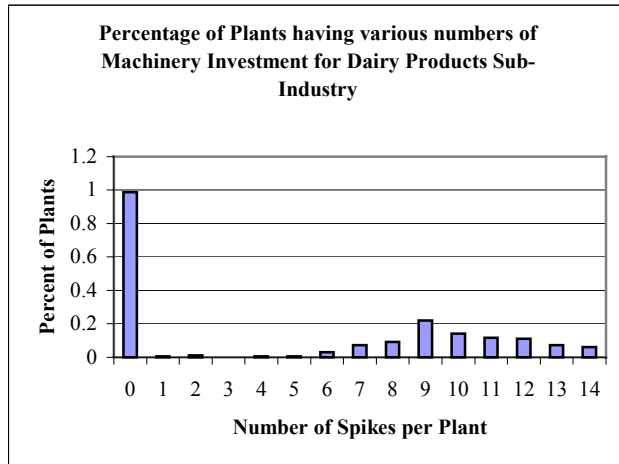


Figure 13. Relative Spike Number for Machinery, Building and Combined Machinery and Buildings Investment Rates

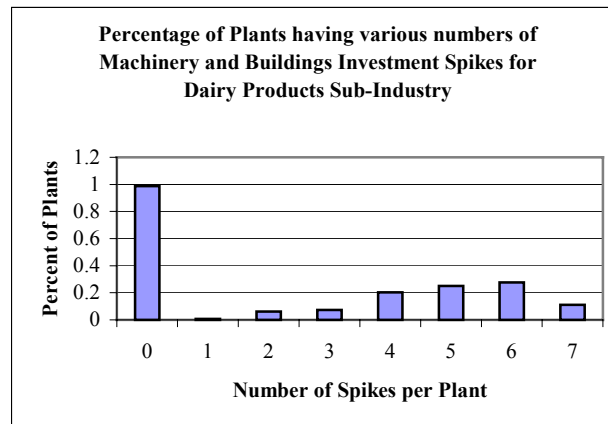
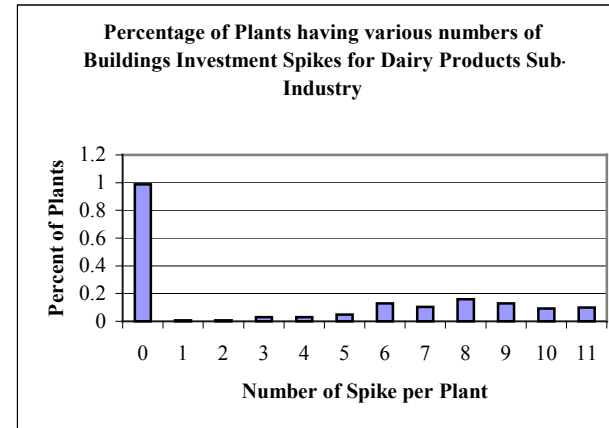
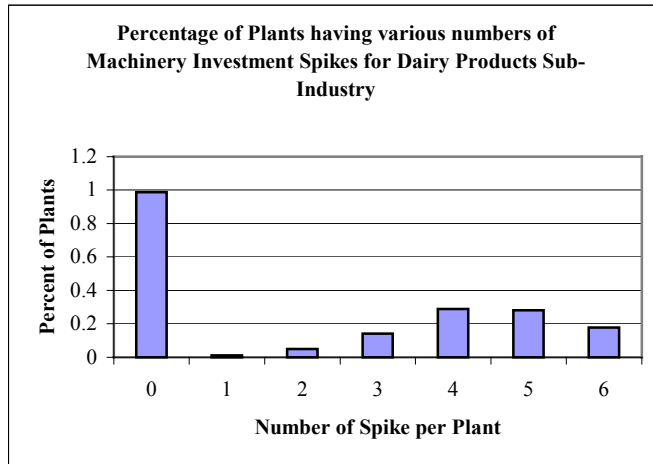


Figure 14. Absolute Spike Number by Years for Machinery, Building and Combined Machinery and Buildings Investment Rates

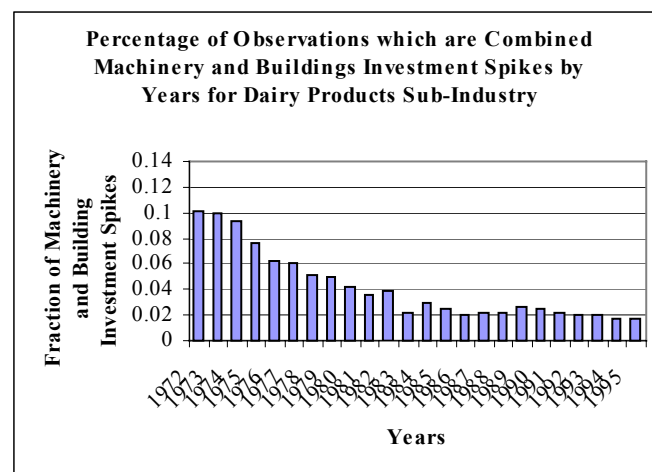
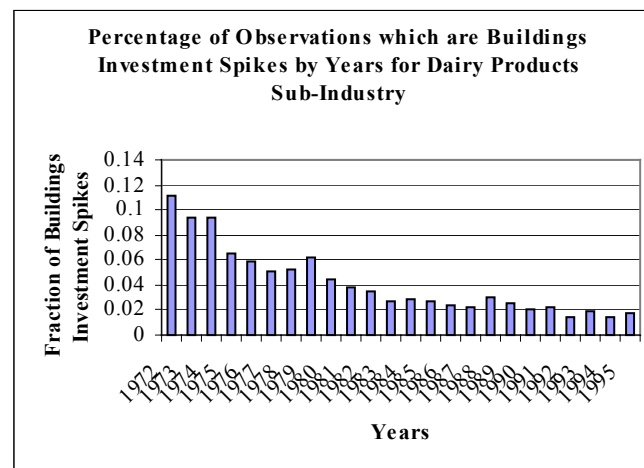
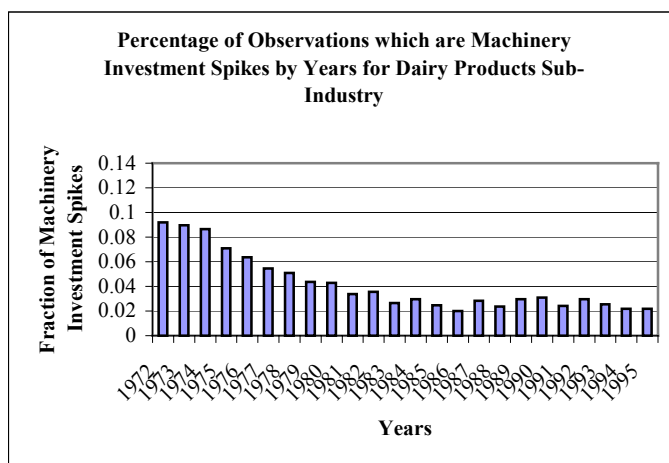


Figure 15. Relative Spike Number by Years for Machinery, Building and Combined Machinery and Buildings Investment Rates

